The Blast Furnace and Steel Plant

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"I am Responsible"

EACH added year brings with it added responsibilities. Civilization—that is our intimate contact with our neighbors, or competitors—neighbors whether in the individual sense of the purely personal, in the corporate sense of the highly organized industrial institution, or in the broader international sense of our government relations—is no longer the simple thing our fathers knew and vaguely understood.

Civilization and our responsibilities to its successful maintenance have become a matter for careful scrutiny, for accurate scaling of its heights and depths, for concise, recorded weighing of its gifts to us and our debts to it.

We must not fail!

Our total scheme is based on accomplishment. Why should we fail with each year's contribution of keener edged tools designed for higher accomplishment?

Nor need we fail!

But we must apply that hard common sense reasoning which is the Scot's gift and which after all has proven the foundation stone of all things built and lasting.

No depths of philosophy need be plumbed. The rules of the game are the same in law, in religion, in science, in education, in recreation, and in business.

Warren C. Drake has expressed them in shining phrase:

"I am responsible only for the Failures of my business. To my associates belongs the responsibility for its Success."

That fine proportioning of responsibilities, and that finer appreciation of the rewards for accepted responsibilities combine together into a working formula well worth carrying forward into daily practice with the New Year's inventory.

Survey of 1926 with Outlook for Future

The Year Is Reviewed Especially with Regard to the Predominant Features—Soundness of Present Industrial Conditions Indicates Future Trend

A SURVEY of the year just passed reveals many impressive features. Some of these features are impressive due to their magnitude, while others not quite so prominent, made possible those features that stand out in bolder relief.

Among the most impressive is the record production established by the steel industry, amounting to 47,000,000 gross tons of ingots. Another is that of the railroads, which, combined, hauled more freight in 1926 than in any other year and recorded the largest increase since 1917. But behind these features are the others, not so much in the foreground, but probably of greater significance. One of these is the spirit of co-operation which pervaded not only the steel industry but others as well. It was this spirit that made possible the establishment of the unprecedented output of steel and other commodities.

Evidence of this spirit of co-operation was particularly apparent in the manner in which the railroads handled the heavy tonnages from the steel mills, and delivered the raw products to them. Automobile companies were able, in the month of August, to deliver 424,394 passenger cars and trucks in comparison with 252,451 in the same month in 1925. This output could not have been reached without prompt delivery of materials and expedited shipments to purchasers.

Close Co-operation.

Another feature which was likewise somewhat obscure to the casual reader was the close synchronization of operations in the various industries as affected by supply and demand. This feature is becoming more prominent and more firmly fixed in our business structure with each passing year. Whether this is due to a better appreciation of the trend of business generally or to a more intimate exchange of opinions among officials of those companies, whose business relations are closely interwoven, is not vital. It is a fact, though, that companies are working in better harmony than heretofore, and are able to adjust plant operations to follow closer the curve of demand. Not only has there been evinced a more pronounced tendency to "get together" between companies, whose interests are along similar lines, but this feeling of good will has likewise extended to employer and employee. That this is the case is evident from the fact that in 1926 there were practically no labor disturbances.

For the creation of such an amicable situation, credit must be given both the workman and the company official. Today it is comparatively easy for an employee to secure an audience with a superior, for the discussion of any grievance, and it is this intimate association that has caused the past year to be so free from dissention.

Are not the activities of 1926 then noteworthy, not alone for the record peaks established, but also for the putting into effect principles of co-operation which before had not functioned to such a high degree of perfection?

In the opening months of 1926 the curve representing new orders was downward, while expressions as to the future were of a very pessimistic nature. The building and automobile trades were not responding as had been hoped and, as these industries consumed, normally, about 30 per cent of the steel output, the outlook was appreciably darkened. A recession in production was expected. Unquestionably these were disquieting features, but basically conditions were sound. Unfilled orders on the books of the United States Steel Corporation on February 1 were 4,882,739 tons.

Improvement Starts in March.

An improvement in tone was apparent in March, but the volume of orders was not as heavy as had been expected. Production was rising gradually, as evidenced by the fact that the Steel Corporation was operating at 97 per cent capacity. Buying was for immediate needs only and continued thus throughout the year. This was one of the features which made 1926 one of the sanest and most conservative of years. There was no evidence of overbuying, hence business proceeded along orderly lines with no violent fluctuations in demand and supply.

Business in April was much better than in the same month in 1925, but orders on the books were gradually decreasing.

Improvement of a decided nature was noted in May and June, while July was one of the most remarkable months the steel industry ever experienced. In that month production was at a maximum. Steel was being consumed as received while prices were firm. The steadiness of prices did much to maintain the steel business on a sound basis. Steel companies were making a very substantial profit, but this was being obtained, not by boosting prices, but by instituting economies in operation. This is another indication of the trend of management in the steel companies. Abnormal prices are probably gone, at least for some years, and, while a fair price will be demanded, profits greater than the average will be realized mainly by a reduction in the cost of operation. Thus cost will be reduced not only by improvements in equipment, but also by the elimination of labor when demands slacken. Economies must be obtained by holding the curve of production close to the curve of demand. In 1926 these two curves were maintained quite closely, which fact accounts in part for the satisfactory results achieved.

Unusual Activity.

July and August were months of unusual activity, greatly exceeding in tonnage the same months of the previous year. Both the automobile and building industries were recording material gains. With the exception of the textile industry, business generally was enjoying a season of prosperity with the outlook for the future promising.

In October shipments to automobile manufacturers showed a decline while production eased off somewhat. Forecasts were not of such an optimistic tenor, all of which was reflected by a drop in the stock market. "Lack of seasonable demand" was brought to the fore and held partly responsible for the slowing up of affairs, but the real cause was not of a "seasonable" nature. Production in the Steel Corporation dropped to 85 per cent of capacity.

During the period of maximum output, which was now tapering off, the railroads had carried the increased volume of freight with most creditable dispatch. This relieved the steel companies from the necessity of storing material ready for shipment. Not only did this rapid movement of steel products benefit the shipper, but it likewise enabled the purchaser to buy on a closer margin as he did not have to carry a large stock. It was a pleasing illustration of the benefits that accrue to all when co-operation functions at its best.

Outstanding Factors.

As the year approached the close production in the steel mills decreased to an average of about 65 per cent. The greatest decline was in the automobile industry and here it was most decided. Prices were kept on the same level as had obtained, but the demands were lacking. Inventories in December were low, which fact again emphasizes the policy of buying only for immediate consumption.

There were many factors which gave steadiness to business generally in 1926. Among these was the maintenance of the curve of prices on practical level lines. This gave stability to the market and assurance to the purchaser so that he could buy freely with no apprehension as to a drop, or a rise, in prices in the immediate future. Another factor was the wise control of finances and the abscence of very wide fluctuations in the stock market.

Railroad Prospects.

Buying by the railroads was considerably below normal and has been for the past two years. As the earnings in 1926 were the largest in many years, railroad buying should be on a much heavier scale in 1927. This increased earning power is the result of an increase in efficiency of operation as well as the haulage of a greater volume of freight. The railroads, like the steel companies, appreciate that increased earnings will be derived not so much from any increase in rates, as these are firmly established, but from more efficient operation, which will result in lower costs. Orders for rails are now being delivered, but this is not particularly impressive as the tonnage placed in the past three years has amounted to only 9 per cent of the rolling capacity of the mills. It may be heavier this year, and if so would be a most welcome addition to the tonnage to be rolled.

It will be of interest to business in general to see the strides that have been made by the power industry. Records were made in revenues received by utility companies and in the production of power. The record of revenues is estimated at about $1,684,000,000, while the power produced amounted, in October alone, to 6,559,000,000 kwh. This is the first time in the history of the industry the power consumed amounted to 6,000,000,000 kwh. per month. Of this immense output 33 per cent was credited to water power. For future expansion the producers of electricity look to railroad electrification and the industries.

Like the ancient Greeks we are ever on the outlook for omens which might portend some future happening either of a gratifying or a direful nature. Like the Greeks, too, we often misinterpret these omens. Thus it is in making a forecast.

Trend for 1927.

What the year 1927 may hold in store for the steel industry is exceedingly difficult to forecast. At the present time there are some unfavorable symptoms. Whether these symptoms may develop to greater proportions or abate, it is impossible to foretell. It is true, though, that the closing days of 1926 do not presage as auspicious an opening for 1927 as did 1925 for the year just passed.

As stocks on hand are low it would appear that a fair amount of business will be forthcoming unless conditions become further depressed. This applies particularly to orders from companies outside the largest consumers.

With the automobile trade comparatively inactive there does not seem to be any great amount of business in sight from this source. Should the buying of automobiles be reserved, there would of course be a revival of manufacturing which would be reflected in increased purchases of steel.

An authority on railroad finances has estimated an outlay from railroads for betterments in 1927 of between $750,000,000 and $900,000,000. A large portion of this expenditure should go directly or indirectly to the purchase of material manufactured by the steel companies. The railroads expect business to be heavy to April 1 at least, as there will be a large tonnage of coal to be handled.

Building industries consume about 15 per cent of the tonnage produced. As this industry is prospering, it is expected that the demand will not slacken to any great extent.

A review of the forecasts from abroad indicates a more hopeful outlook for 1927. It is hard to understand how conditions could be worse than they were in 1926, especially in England, where conditions were most depressing due to the general strike and with labor generally dissatisfied.

There has been a well supported demand from the oil and gas companies which has been strong enough to encourage the installation of equipment for decreasing the cost in the manufacture of tubes, etc. Several of the leading steel companies have contracted for machinery by which tubes can be produced according tō a process now carried out in Germany.

The Outlook for the coal industry is not particularly bright. Demand for bituminous coal has been of a fluctuating nature, and will likely continue so. The coal strike in England caused an increase in output in 1926, but this was not felt generally among producers, as the tonnage was met by augmented output in a few fields.

Summary of Metallurgical Developments

A General Review of Metallurgical Advancement for 1926 Is Presented with Suggestions as to Further Improvements in the Melting and Treatment of Iron and Steel

By S. L. GOODALE*

THE past year has been one of continued development in many varied lines in metallurgy; but it is difficult to pick out any developments of startling newness. Perhaps the most outstanding feature of the year has been the increased interest of practical men in the open hearth and blast furnace divisions of the industry in the recent researches in those fields from a scientific standpoint. It seems that the practical men are ready to listen more than ever before to the voice of science as applied to industry.

The large hearth blast furnace with its increased wind, its great capacity, and its economy, has become more nearly the present American standard. Yields of 800 tons per day are not unusual; and the coke per ton of pig iron is notably below that of a few years ago. Moreover, the coke now used is almost entirely from retort ovens; and careful attention is paid to the recovery of by-products. There is, however, the feeling among many open hearth men that iron made under conditions of rapid output is not ideal for steel making, that reduction is perhaps not so complete, and that the blast furnace is the place were the elimination of impurities should be accomplished.

Larger Open Hearth Furnaces.

Some very large stationary open hearth furnaces, also, have been built; of nominal capacities of some 250 tons. These require the bifurcated spout for tapping into two ladles. Much interest continues to be shown in the important question of improved refractory materials which will permit higher flame temperatures and hotter and more effective working and refining. Improvements along this line will probably be the answer to greater blast furnace production of less desirable quality iron. Another feature of considerable interest has been the use of iron, of some 1.5 per cent to 2 per cent of manganese, and the additions of manganiferous ore in the open hearth furnace. When properly used these additions permit savings in fluorspar, lime and ferro-manganese, and result in the production of low sulphur steel. This question of sulphur-control seems, at last, to be well understood and this control is now generally admitted to come under physico-chemical laws of distribution, so that to obtain low sulphur steel the gas and slag materials must be low in sulphur. The question of the quantity of sulphur permissible in steel for specified uses is still an open one.

Develcpments in Strip Mills.

Some developments in continuous strip mills, for rolling wide strips, have been made during the year. Another development in continuous mills is that at the new Ford mill at Fordson. The practice there is to teem ingots of 1500 lbs., with hot tops, in order to secure a minimum of segregation and pipe. Six ingots are cast simultaneously by means of a six spouted tun dish. These ingots are rolled in a semi-continuous 42-inch mill, of six stands, followed by six stands of 32-inch rolls. Some novel handling appliances have been adopted, as well as certain novel features in the roll stands themselves. The Ford installation was designed for a very large output, 100,000 tons per month; and it is interesting to note the efforts that have been made to secure high quality of product in a plant with large production. More and more this feature of quality forces itself upon the attention of the tonnage producers. New schemes are being perfected for the drawing of wire by continuous processes. Other rolling mill developments include improvements made in the Gray mill.

Foundry Research.

In foundry work the subject of the testing of materials was very prominently considered at the International Foundry Congress in Detroit. The need of getting test pieces that will represent the casting, or will represent it in the most reliable manner, was particularly emphasized. The importance of the correct heat treatment of the molten iron in order to secure high duty castings was discussed. The idea advanced was to melt, and treat the metal at a temperature well above the minimum necessary merely for melting, and then to allow it to cool to a point slightly above its setting point. When one considers the importance of the temperature, at which many chemical processes are conducted, it would seem that far too little attention has been paid in iron and steel metallurgy to the possibilities of forcing desirable reactions by temperature control of the liquid metal. Sand control for molding has received attention in research work, and the results point to an even wider use of sands mixed synthetically to secure bonding power, porosity, refractoriness, etc., in place of the natural sands alone.

Welding Replaces Rivets.

Interest in welding, especially by the electric arc, is growing. Some seven hundred tons of steel has been fabricated by arc welding in constructing the five-story building of the Westinghouse Company at Sharon, Pa. It is stated that 800 tons would have been required for the same structure if the standard riveted construction had been adopted. Methods of welding under cover of a stream of hydrogen, recently developed by Dr. Irving Langmuir at Schenectady, and by Mr. Alexander at Lynn, give much promise of usefulness in many applications. Welding of unlike metals, as copper to steel, or to stainless steel, etc., is claimed to be a possibility. The welds under hydrogen are said to be ductile, and of a quality equal to that of the metal welded. Presumably, they can also be subjected to heat treatment for further betterment. Fusion welding, originally used only for repair and odd jobs, is now of much use in many production lines.

Chromium plating appears to have developed satisfactorily. The costs are necessarily somewhat higher than for nickel plating; but the great hardness of the chromium and its resistance to corrosion make it very desirable for certain purposes, where resistance to wear is desired, as in gauges and some engravings for printing large number of impressions from a plate, etc. In such cases it may give as much as 10 to 20 times the service of hardened steel.

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There are not many instances where metals of extreme purity are required, but one of the most important aids in the effort to improve our knowledge of metals for commercial use, is the ability to get pure metals for scientific study. This subject was discussed at a meeting of the New York City section of the American Electro-chemical Society, and covered copper of 106 per cent conductivity, aluminum, nickel, zinc of 99.99996 per cent purity and tin. While the amount of electrolytic iron is not large, still there is already a certain production for some special uses.

Many other individual developments and technical reports of interest and value, might well be mentioned in a more complete review of the year. The general trend of the industries is towards further technical control of processes, and the adoption of these processes as soon as they have been proven correct in practice.

Review of Iron and Steel Literature

This Review Covers Those Publications Having a Bearing on Geology, Metallurgy, Economics, Forging and Foundry Practice, and Other Allied Fields

By E. H. McCLELLAND*

THIS list constitutes the tenth annual review of iron and steel literature compiled for THE BLAST FURNACE AND STEEL PLANT. An attempt has been made to list the more important publications of 1926, together with certain publications dated 1925 but not available for inclusion in the list compiled near the end of that year.

Where possible, the compiler has examined the publications listed, but in some cases the publications were not accessible and the only information regarding them was in technical journals and publishers' lists, which, unfortunately, are not always either accurate or complete. Prices are sometimes particularly hard to verify promptly, certain sources of information occasionally differing very widely. The prices here given are, therefore, probably in some cases incorrect.

Some official publications of the United States government have been grouped at the end of this list, but space is not available for inclusion of all the material appearing serially. The "Industrial Standards" series of the Bureau of Foreign and Domestic Commerce includes a number of specifications for iron and steel products. These are standards adopted by the American Society of Testing Materials, published with text in English and Spanish, and priced at five cents each. The "Berichte der Fachausschüsse des Vereins deutscher Eisenhüttenleute" appears as a series of pamphlets covering a wide array of metallurgical and furnace problems. Prices vary according to the number of pages.

GENERAL

Geology, Ores, Mining.

Bayley, W. S. Deposits of Brown Iron Ores (Brown Hematite) in Western North Carolina. 76 pp. 1925. North Carolina Geological Survey, Raleigh. (Bulletin 31.)

Collins, W. H., and others. Michipicoton Iron Ranges. 175 pp. 1926. Canada Department of Mines, Ottawa. 30 cents. (Memoir 147. Geological Series 127.)

Crawford, R. D., and Gibson, R. Geology and Ore Deposits of the Red Cliff District, Colorado. 89 pp. 1925. Colorado Geological Survey, Boulder, Colo. (Bulletin 30.)

Three folded maps in pocket.

Kukuk, Paul. Deutschlands Kohlen- Kali- und Eisenerzlagerstätten. Ed. 5. 1925. Georg Westermann, Brunswick.

Lake Superior Iron Ore Association. Directory of Lake Superior Iron Ore Industry. 1926. The Association, Cleveland.

Includes also statistical material. To be published annually.

Pickands, Mather & Company. Analyses, Lake Superior Iron Ores. 19 pp. 1926. Cleveland.

Metallurgy, Testing, Working.

American Iron and Steel Institute. Year Book. 436 pp. 1926. The Institute, New York. $5.

Benedicks, Carl. Metallographic Researches. 307 pp. 1926. McGraw-Hill Book Co., New York. $4.

Includes lectures delivered in United States in 1925. Contains considerable material not previously published or published only in Swedish. Covers various unrelated topics, but is concerned mainly with ferrous metals.

Bethlehem Steel Company. Bethlehem Stainless Steel and Stainless Iron. 18 pp. 1926. The Company, Bethlehem, Pa. (Booklet No. 113.)

Brearley, H. Die Einsatzhärtung von Eisen und Stahl; berechtigte deutsche Bearbeitung von Rudolf Schäfer. 249 pp. 1926. Julius Springer, Berlin. 19.50 m.

German translation of "Case Hardening of Iron and Steel."

British Engineering Standards Association. British Standard Tables of Brinell Hardness Numbers. 21 pp. 1926. The Association, London. 1sh.

Cammen, Leon. Principles of Metallurgy of Ferrous Metals; a Manual for Mechanical Engineers. 145 pp. 1926. American Society of Mechanical Engineers, New York. $2.

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*Technology Librarian, Carnegie Library of Pittsburgh.

Cancel, F. Manuel pour l'échantillonnage et l'analyse du charbon. 135 pp. 1925. Ch. Béranger, Paris. 16 fr.

Dejean, Pierre. Actualités métallurgiques. 283 pp. 1925. Dunod, Paris. 36 fr.

Includes sections on special steels and on tempering. Preface by A. Sauveur.

Döhmer, P. W. Die Brinellsche Kugeldruckprobe und ihre praktische Anwendung bei der Werkstoffprüfung in Industriebetrieben. 186 pp. 1925. Julius Springer Berlin. 18 m.

Faraday Society. Physical Chemistry of Steel Making Processes. pp. 169-296. 1925. The Society, London. 8sh. 6d.

Forms the "Transactions," vol. 21, part 2, December 1925. A series of papers and a general discussion held by the Faraday Society and the Iron and Steel Institute.

Firth (Thomas) & Sons, Ltd. Development of "Staybrite" Steel. 96 pp. 1926. The Company, Norfolk Works, Sheffield. 12sh. 6d.

Grenet, L. Trempe, recuit, cémentation et conditions d'emploi des aciers. Ed. 3, 655 pp. 1926. Ch. Béranger, Paris.

Günther, Hanns. Der Weg des Eisens vom Erz zum Stahl. Ed. 3, 109 pp. 1925. Dieck & Co., Stuttgart. 5.50 m.

Illustrated, descriptive work.

Hanemann, H., and Schrader, A. Über den Martensit. 25 pp. 1926. Verlag Stahleisen, Düsseldorf. 6 m.

Heyn, E. Physical Metallography; translated and enlarged by Marcus A. Grossmann. 440 pp. 1925. John Wiley & Sons, New York. $6.

Author was a recognized leader in metallographic research in Germany. Much of the work is highly theoretical, and the translator has rendered a valuable service, not only in making the original treatise available in English, but in summarizing more recent developments, and in providing a new chapter on iron and steel, presenting theoretical conceptions, and discussing briefly the important alloy steels.

Houghton (E. F.) & Company. Houghton's Liquid Baths for the Heat Treatment of Steel. 158 pp. 1926. The Company, Philadelphia. Free.

Though concerned in part with the use of products made by this company, the book gives much general information on processes and equipment.

Hurst, J. E. Metallurgy of Cast Iron; a complete Treatise for Engineers, Foundrymen, and Students. 311 pp. 1926. Sir Isaac Pitman & Sons, London. $4.50.

Iron and Steel Institute. Journal. Vol. 112, 577 pp. 1925; vol. 113, 747 pp. 1926. The Institute, London.

Contains abstracts constituting the best existing guide to the current literature of ferrous metallurgy.

Jominy, W. E. Investigation of Charcoal and Coke Pig Irons. 27 pp. 1926. University of Michigan, Ann Arbor. (Engineering Research Bulletin 1.)

Jones & Laughlin Steel Corporation. Jalcase Steel; Hot Rolled or Cold Finished. 48 pp. 1926. The Corporation, Pittsburgh. Free.

Trade literature dealing with "a new free-cutting Open Hearth Steel, especially adapted for Case Hardening and Heat Treating and for Forging where machinability is important."

Kaiser-Wilhelm-Institut für Eisenforschung zu Düsseldorf. Mitteilungen; edited by Friedrich Körber. Verlag Stahleisen, Düsseldorf.

Issued serially in "Lieferungen," varying in size and price. Parts of vol. 7-8 appeared during 1926.

Kropf, Alfred. Laboratoriumsbuch für den Eisenhütten- und Stahlwerks-Chemiker. Ed. 2, revised by M. Orthey. 104 pp. Wilhelm Knapp, Halle a. S. 5.20 m.

Larsen, B. M., and others. Service Conditions of Refractories for Open-Hearth Steel Furnaces. 127 pp. 1925. Carnegie Institute of Technology, Pittsburgh. $1.50. (Mining and Metallurgical Investigations, Bulletin 25.)

Co-operative work with the U. S. Bureau of Mines.

Leeds & Northrup Company. The Hump Method for the Drawing of Steel. 19 pp. 1925. The Company, Philadelphia. (Catalog No. 93.)

Leeds & Northrup Company. The Hump Method for Heat Treatment of Steel. 40 pp. 1926. The Company, Philadelphia.

In heat treatment, the curve traced by the recording pyrometer shows a "hump" at the critical range during which the steel absorbs heat, without rise in temperature. It is from this phenomenon that the process takes its name, the operation depending, not upon the recorded temperature, but upon the appearance of the "hump."

Linde Air Products Company. The Oxygen Lance in Blast Furnace and Steel Plants. Ed. 3, 44 pp. 1925. The Company, New York. Free.

Discusses uses in operation of blast-furnace and open-hearth furnace, and in cutting ingots and other large masses of metal.

Lipine, V. N. Metallurgy of Cast-Iron, Wrought-Iron, and Steel. Ed. 2, vol. 1, 1925. Leningrad.

Printed in Russian.

Lynch, T. D., and Steidle, Edward. Progress Report of Metallurgical Advisory Board to Carnegie Institute of Technology and United States Bureau of Mines, January 1923, to January 1926. 32 pp. 1926. Carnegie Institute of Technology, Pittsburgh. (Mining and Metallurgical Investigations, Bulletin 27.)

McClelland, E. H. Review of Iron and Steel Literature for 1925. 12 pp. 1926. Carnegie Library of Pittsburgh, Pittsburgh. 5 cents.

Reprinted from "Blast Furnace and Steel Plant," and "Forging-Stamping-Heat Treating," 1926.

McClelland, E. H., and Polansky, V. S. Manganese Steel; a Bibliography, with Preface by Sir Robert Hadfield. 60 pp. 1926. Carnegie Library of Pittsburgh, Pittsburgh. 5 cents.

Published in "Blast Furnace and Steel Plant," December 1924, August and September 1926; and in part in "Forging-Stamping-Heat Treating," February 1925.

McIntosh, F. F., and Cockrell, W. L. Effect of Phosphorus on the Resistance of Low-Carbon Steel to Repeated Alternating Stresses. 33 pp. 1925. Carnegie Institute of Technology, Pittsburgh. 50 cents. (Mining and Metallurgical Investigations, Bulletin 25.)

Co-operative work with U. S. Bureau of Mines.

Melaney, W. H. Modern Sheet Mill Practice with the Logic of Roll Design. 116 pp. [1926.] n.t.p. Author, National Roll and Foundry Co., Avonmore, Pa.

Title from cover of book. Most of the material appeared serially in "Blast Furnace and Steel Plant."

Mochel, N. L. Stainless Iron. 353-391 pp. 1926. Author, Westinghouse Electric and Manufacturing Co., South Philadelphia.

Reprinted from "Transactions of the American Society for Steel Treating," September 1926.

Monypenny, J. H. G. Stainless Iron and Steel. 304 pp. 1926. Chapman & Hall, London. $6.

History, manufacture, properties, and uses of high-chromium-bearing steel.

Moore, H. F. Tests of the Fatigue Strength of Cast Steel. 20 pp. 1926. University of Illinois, Urbana, Ill. 10 cents. (Engineering Experiment Station, Bulletin 156.)

Moore, H. F., and Jasper, T. M. An Investigation of the Fatigue of Metals, Series of 1925; a Report of the Investigation Conducted by the Engineering Experiment Station, University of Illinois, in Coöperation with the National Research Council, the Engineering Foundation, the General Electric Company, the Allis-Chalmers Manufacturing Company, the Copper and Brass Research Association, the Western Electric Company. 92 pp. 1925. University of Illinois, Urbana, Ill. 50 cents. (Engineering Experiment Station, Bulletin 152.)

Pitois, E. Le grain de l'acier. 38 pp., 64 plates. 1926. Ch. Delagrave, Paris.

Photomicrographs, with brief text.

Ros, M. Der neue F-Stahl. 19 pp. 1926. Eidgenössische Materialprüfungsamt, Zurich.

Ruhrmann, E. Bordeln und Ziehen in der Blechbearbeitungstechnik. 35 pp. 1926. V. D. I. Verlag, Berlin. 6 m.

Sachs, Georg. Grundbegriffe der mechanischen Technologie der Metalle. 319 pp. 1925. Akademische Verlagsgesellschaft, Leipsic. 15 m.

Sauveur, Albert. Metallography and Heat Treatment of Iron and Steel. Ed. 3, 535 pp. 1926. University Press, Cambridge, Mass. $8.

Sellin, W. Die Ziehtechnik in der Blechbearbeitung. 60 pp. 1926. Julius Springer, Berlin. 1.50 m.

Sisco, F. T., and others. On the Metallurgy of Iron and Steel. 193 pp. American Society for Steel Treating, Cleveland. $2.

Three papers reprinted from "Transactions" of the Society. Includes Bengt Kjerrman on Swedish practice, and Birger Egeberg on electric melting.

Sperr, F. W., Jr. The Purification of Open Hearth Fuel Gas. 27 pp. n.d. Koppers Co., Pittsburgh.

"Part of the material . . . was presented in an address before a meeting of the Eastern States Blast Furnace and Coke Oven Association in Youngstown, Ohio, June 4, 1925."

Stoughton, Bradley, and Butts, Allison. Engineering Metallurgy; a Textbook for Users of Metals. 441 pp. 1926. McGraw-Hill Book Co., New York. $4.

Deals only in part with ferrous metals. Primarily for engineering students who will not take advanced work in metallurgy, but will deal with uses and applications of metals.

United States Steel Corporation. Methods of the Chemists of the United States Steel Corporation for the Sampling and Analysis of Iron and Manganese Ores. Ed. 3, 148 pp. 1926. Carnegie Steel Co., Pittsburgh. $2.

Walker, J. Bernard. Story of Steel. 208 pp. 1926. Harper & Brothers, New York. $4.

Popular account of manufacture of steel, discussing the more important products, and giving some attention to safety, welfare work, finances, and marketing of products.

Wall, G. P. Heat Treatment of Steel. Ed. 3, revised. 115 pp. n.d. Magneto Steel and Wire Works, Sheffield, England.

Trade literature, containing useful information.

Whitworth (Sir W. G. Armstrong) & Company, Ltd. Steels for General Purposes. 86 pp. The Company, London.

Woodward, W. E. Metallography of Steel and Cast Iron. 143 pp. 1926. Crosby Lockwood & Son, London. 15sh.

Elementary text-book with photomicrographs of typical steels.

Economics, Statistics, Directories, History.

American Iron and Steel Institute. Annual Statistical Report for 1925. 101 pp. 1926. The Institute, New York.

Figures of production, imports, exports, and prices for United States and Canada.

American Iron and Steel Institute. Directory of the Iron and Steel Works of the United States and Canada. Ed. 20, 493 pp. 1926. The Institute, New York. $15.

Andresen Company, Inc. Directory Giving List of Companies and Officials Operating Blast Furnaces, Steel Plants, Rolling Mills, By-Product Coking Plants, Structural Steel, Boiler and Tanks, Railroad Shops, Forging, Heat Treating and Stamping Plants in the United States and Canada. 438 pp. 1926. Pittsburgh. $10.

Burchard, Ernest F., and Davis, H. W. Iron Ore, Pig Iron and Steel in 1924. Published May 14, 1926. Government Printing Office, Washington, D. C.

Advance publication of pp. 297-333 of the United States Bureau of Mines "Mineral Resources of the United States, 1924," part 1.

Comité des Forges de France. Annuaire, 1925-1926. Paris. 50 fr.

Directory of the steel industry with alphabetical and geographical arrangement.

Delmer, A. Belgian Iron and Steel Industry. 12 pp. London and Cambridge Economic Service, London.

Friend, J. Newton. Iron in Antiquity. 221 pp. 1926. Charles Griffin & Co., London. $5.

Hardware Age Verified List. 627 pp. 1926. Hardware Age, New York. $12.

Classified directory of the hardware industry of the United States.

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Developments in the Open-Hearth Process

A Very Complete Review of Furnace Construction and Operation Is Given—Metallurgical Practices Are Discussed at Length (with Chemical Equations)

By B. M. LARSEN

THE year 1926 was a very active period in American open-hearth shops. With a record monthly ingot production in March of 166,236 gross tons per day and a record open-hearth output of 34,747,105 gross tons during 11 months, most shops were worked nearly to capacity and many production records were broken. Towards the end of the year there was a slackening of orders to about 70 per cent of capacity. A few shops have built new furnaces and many plants are remodeling or rebuilding their old furnaces along the lines of later developments. Nearly all new construction, of course, follows conservative design established by slow developments through many years of trial and error.

The new open-hearths of the Weirton Steel Company represent perhaps the latest development in design. These are stationary furnaces, of 250 tons capacity with an extra deep bath to contain this large weight of metal. They are built with a forked tapping spout, arranged so that two ladles can be filled at the same time. These furnaces will supply metal for a large sheet mill of radically modern design. The new open-hearth plant of the Ford Company[18] includes four 100-ton tilting furnaces, equipped with waste-heat boilers. Like most construction by the Ford Company this shop is apparently a model in design for neatness and convenient working conditions. The metal is teemed into a large number of 1500-lb. ingots, using inverted molds, hot tops and a specially designed pouring dish arranged so that four ingots may be teemed at one time.

Physics and Chemistry of Steel-Making.

The really unique development relating to open hearth steel-making in late years is the rapid increase in our knowledge of the physics and chemistry of the process. More than in almost any other industry, the science of steel-making has always been subordinate to the art of steel-making. This is largely due to the lack of physical constants for such high temperatures, and to some extent also to the necessarily unfavorable conditions for careful research measurements which exist around a steel plant. But science is rapidly catching up in the last few years and is beginning to rationalize or explain away the empirical rules developed by years of practice. Knowledge in methods of control of combustion, temperature measurements, and methods of improving thermal efficiency is also rapidly increasing. Some of the recent developments of this kind can at least be briefly indicated here.

Temperature Measurement and Control.

We still lack, and are in great need of, a workable method for measuring metal temperatures in the bath of an open-hearth furnace during a heat. Recent work[12] indicates that temperatures of slag and roof surfaces may be determined very accurately with an optical pyrometer, by sighting through small openings with the flame cut off. The melting chamber surfaces are always kept at nearly equalized temperatures by radiation interchange, except for the early part of a heat. The furnace thus becomes practically a black body for sighting on with a pyrometer, if the flame is cut off just before reading temperatures. The presence of flame causes high readings by reflection from the walls or slag of its more intense radiation.

Recent work (Huessener,[4] for example) on the measurement of gas temperatures with radiation-protected pyrometers has shown more and more clearly that gas temperatures taken for all the published open-hearth balances must be rather seriously in error. An

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Numbers refer to bibliography at end of this paper.

unprotected pyrometer placed in a gas stream receives heat both from the gas by convection and from the surrounding walls by radiation, and its readings are in error unless walls and gas are at nearly the same temperatures. As a rule, outgoing gas temperatures as measured are low, and incoming air temperatures are much too high in most cases. In a radiation-protected pyrometer, a thermocouple is placed inside two concentric tubes through which the hot gases are drawn at a rather high velocity by steam jets. The outer tube may be insulated for further protection from radiation, and with such a pyrometer, air preheat, outgoing gas or checker chamber temperatures may be measured quite accurately.

Automatic Control of Combustion.

Results given by Huessener[4] indicate rather marked economies in fuel consumption and increased production rates made possible by automatic regulation of the fuel and air supplied to a furnace. This is not surprising, for, considering the importance of the open hearth, not much careful study has been given to exact control of combustion. Especially in the older furnaces, very large quantities of air and combustion gases filter in and out of the circulating system through cracks in the brickwork. Nearly all furnaces depend entirely upon chimney effects for circulation and do not usually have very exact control of dampers, so that the amounts of excess air in gases leaving the combustion chamber often vary widely during each heat and also during a campaign, as the checkers clog up and the air available by natural draft decreases.

Huessener[4] advocates installing an induced draft fan to regulate the air supply to the regenerators, and, in addition, on producer-gas furnaces, a turbine blower to supply air to the producers. He designed an automatic combustion regulator which maintains a constant controlled ratio between the amount of air supplied to the regenerators and the amount blown into the producers (or the volume of fuel gas in natural gas or coke-oven gas furnaces.) He gives figures, for example, comparing producer-gas furnaces with and without automatic control, and shows that controlled combustion increased production from 5790 tons to 6625 tons per furnace per month, and fuel consumption was reduced from 550 to 513 pounds per ton of steel. In applying such close control to a furnace it is advisable to reduce the volume of infiltrated air by building the walls of checker chambers, uptakes, etc., as tight as possible.

Waste-Heat Boilers.

The slowly increasing number of installations of waste-heat boilers in open-hearth plants has stimulated research[15] in their design and efficiency. Results appear to indicate that the fire-tube boiler has the following advantages over water-tube boilers for such service: (1) The tubes are easier to clean of dust deposits. This is important because of the large amounts of fine iron oxide dust carried in the waste gases. (2) The fire-tube design apparently gives a better transfer of heat for a given resistance to gas flow. A fan of ample capacity must be installed to take the place of the stack to overcome this added resistance, and it is desirable to minimize the pressure drop through the boiler. In an ordinary coal-fired boiler the water-tube design is superior, but there most of the heat transfer is by radiation at higher temperatures. At the lower temperature ranges in waste-heat boilers, however, heat transfer by convection predominates and the fire-tube boiler gives more intimate contact between all the gas and the heating surface.

Insulation.

The use of insulation progresses very slowly in open-hearth shops. A few plants have begun to insulate their checker chambers. The use of waste-heat boilers has tended to hasten this development, because insulated checkers and tunnels give higher waste-gas temperatures and an appreciable increase in the amount of steam generated. A few small foundry furnaces, at least, have been successfully operated with insulated checker chambers, downtakes, port end walls and port arches.

The net thermal efficiency of an uninsulated furnace is usually in the range of 2 to 8 per cent. If we had a refractory equal in properties to silica brick, but with its effective softening range about 100 deg. C. higher, for use in roof arches and upper sidewalls, it would be quite possible to insulate the whole furnace structure and obtain increased production rates, higher thermal efficiencies, and longer life from refractories. Even with the present refractories available it should be theoretically possible to operate a completely insulated furnace; the only condition would be that the inner surface temperatures throughout the melting chamber must then necessarily be maintained always below a maximum of about 2950 deg. F. Such perfect control is almost impossible under the conditions in the average open-hearth shop. This makes it impracticable to insulate the silica roof arch and sidewalls of the melting chamber. The inner surface temperature of the arch must nearly always be equal to or above the bath temperatures, which must at times be raised to temperatures only 50-100 deg. F. below the softening temperatures of the silica arch (2975-3000 deg. F.) Occasional overheating of the roof thus becomes almost inevitable, and such overheating would probably cause rather disastrous results with an insulated arch. It should be quite feasible to insulate the remainder of the furnace structure, however, including the hearth, tunnels, checker chambers, and downtakes, and probably also the port end walls and port arches. Such developments may come in time and a study of their effects on furnace operation and efficiency should be very interesting and valuable.

Water-Cooling.

The practice of water-cooling the metal parts of the open-hearth structure seems to be gradually increasing. In contrast with this tendency there is evidence of a general decrease in the use of various special coolers designed to protect the refractories in certain parts of the furnace structure, such as bulkhead, slag line, and backwall coolers, port arch and port end wall coolers, etc.

Laboratory tests on water-cooled walls support this tendency. It is found that a layer of refractory backed up by a cooler will wear away by corrosion or fusion at almost the same rate as if the water-cooler were not there; also, the resistance to flow of heat across the boundary between refractory and water cooler surface is large enough so that a wall may be cooled just about as effectively by exposure to free radiation and air-cooling as with a water-cooler against the wall. Where water-cooled metal surfaces are directly exposed inside the furnace chamber, a limited portion of the lining near or behind the water coolers is definitely stabilized and protected, but this effect is obtained only at the cost of a large loss of high-temperature heat which is radiated to and absorbed by these cool metal surfaces.

In general, water-cooling is to be regarded as a last resort to be used only when no improvements in design, operation, or refractories will give sufficient durability to a certain part of the furnace structure. For example: The use of water-cooled parts around the throat of a gas port in a producer-gas furnace is necessary, because no refractory tested to date has been able to withstand for long the high temperatures and intense corrosive action on outgoing port surfaces, which must be maintained in good shape to give proper combustion and flame direction.

As compared to cooling for protection of refractories, the cooling of metal parts of the furnace framework is much more rational and feasible, because metal parts have so much higher conductivities and if necessary, the cooling water may flow in direct contact with the metal to be cooled. Such cooling does not appreciably increase the rate of heat loss from the furnace while it tends to prevent buckling and bending of the framework, and, in the case of cooled doors and door frames, causes much more comfortable working conditions around the furnace.

Refractories.

Little progress has been made recently in the application of new refractory bodies to open hearths. The use of patent "Metal-Kase" magnesite shapes in sidewalls of the melting chamber has definitely failed. Temperatures are so high in this zone that the steel cases melt away before they can oxidize and sinter the magnesite cores together to form a solid wall. For port end walls, however, these shapes have shown definite improvement over silica.

Chrome brick have also been used successfully in port end and upper downtake walls. Many plants have been using from one to six courses of chrome brick in lower sidewalls, and in few cases this has extended to the construction of whole backwalls and frontwalls of chrome brick, with fair success. One plant is building back and front walls of alternate courses of silica and chrome. Chrome brick have also proved superior to magnesite in backwalls of Talbot furnaces.

The Carborundum Company has recently announced the development of a new high-temperature insulating brick, made by burning clay mixed with sawdust to form a porous clay body. If produced cheaply enough, such brick may possibly find a future use for the insulation of certain parts of the open-hearth structure. They will stand a higher temperature than the common insulating brick made from diatomaceous earth. The Corning Glass Company has developed refractory blocks made by casting mullite from the liquid state. They give very superior service in glass tank furnaces, and while they have not yet been tested in open hearths, there are possibilities of such application.

Though we progress very slowly in the development and use of new bodies, recent studies of service conditions[12] have made possible a much more accurate description of the causes and modes of failure of various refractories under open-hearth conditions. At temperatures around 1600 deg. C., iron has a vapor pressure of about 1 millimeter of mercury. The slag layer in a furnace tends to become saturated with iron vapor, and the large volumes of gas evolved from the bath contain appreciable amounts of iron vapor. This metal vapor, oxidizing above the bath to form a fine mist or fume of iron oxide, is carried suspended in the gas stream. Such iron oxide fumes (together with small amounts of manganese oxide formed in a similar manner and of CaO and MgO from the dusting of lime and dolomite) are carried by the gas streams to all ports of the structure and either deposit on surfaces, or in higher temperature zones, saturate the porous structure of the refractory walls and slowly wear away the brick by fluxing corrosion. With the exception of the hearth and lower sidewalls in the melting chamber, the brick surfaces are subject to corrosion only by this oxide fume, composed mainly of iron oxide.

A new silica brick roof reacts with these oxide fumes to form a liquid phase which soaks into and saturates its porous structure for a distance of 4 to 6 inches from its inner surface. During the first 5 to 10 days of a campaign, something like 2 or 3 tons or more of iron oxide will be absorbed by the brick in the roof arch of a 100-ton furnace. After the brick are saturated, the oxide fumes corrode away the inner surface and slowly wear away the roof. These flux-saturated silica brick have a minimum softening range at about 2975-3000 deg. F. Whenever wall temperatures exceed this range (which is only about 50-100 deg. F. above the normal range of finishing temperatures during steel-making) the mode of failure changes from that of surface corrosion by fluxes to that of softening and fusion of the brick. These two effects are largely independent of each other; the latter is caused by imperfect control in operation and overheating of the furnace, while the former is an inevitable result of necessary conditions in steel-making.

Chrome brick have much more resistance than silica to either fusion or corrosion by iron oxide fumes or slag, but have a greater tendency to fail by spalling. When a new chrome brick is placed in a backwall, for example, its inner surface begins at first to soak up fluxes or slag. After a few days of service the inner zone of the brick for a depth of 1 to 3 inches is changed to a dense, vitreous body. This vitreous zone has an increased tendency to chip and spall away as the result of variations in furnace temperatures and this mode of failure becomes the chief cause of deterioration of chrome brick in service.

Suspended Roof Arch.

The suspended type of roof has been given sufficient trial in industrial furnaces to show its value and its limitations. As silica shapes are used, the rate and conditions of deterioration by either surface corrosion or fusion are absolutely unchanged by the use of a suspended arch construction. The spalling of roof blocks may be somewhat lessened, but not eliminated with this construction. Two general modes of spalling occur in a silica roof: (1) The pressure between blocks caused by expansion strains often causes a mechanical breakage of blocks or chipping of corners. This cause of spalling is absent in a suspended roof, as nearly all the pressure between shapes is relieved. (2) Spalling also results from internal strains caused by temperature changes, re-crystallization and expansion and zone formation due to flux saturation of the silica brick. This mode of spalling is not affected by suspending the arch brick.

Theoretically, it should be possible to remove and replace spalled blocks and those around badly burned areas of a suspended arch while the furnace is hot. This advantage is not realized in practice because the silica shapes fuse together at their inner ends and are difficult to remove or replace. Hot patching must usually be done in the old way used with ordinary roofs. However, when the furnace is cooled down for repairing port ends or sidewalls or for cleaning checkers, any badly worn parts of a suspended arch may be replaced without injuring the remainder of the roof. This is the really important advantage of the suspended arch construction. Results obtained look encouraging for the increased use of suspended arches.

Sloping Backwalls.

Several plants have changed some of their furnaces to sloping backwalls, with almost universal success. The change is usually made by bending the buckstays out at an angle for a short distance beginning about at the slag line. Steel plates are laid on this sloping section and the hearth brick extended upward on this sloping section. The skewback is lowered 6 to 10 inches to allow for the increased width of roof arch. The hearth thus extends nearly to the roof and the backwall can be patched with magnesite, dolomite, or chromite, in the same way as the hearth and banks. These backwalls appear to last almost indefinitely compared to the old vertical walls, and give one or two years of service, at least, without rebuilding.

Pig Iron for the Open Hearth.

Most American open-hearth operators prefer to use pig-iron with silicon in the range of 0.80-1.30 per cent; sulphur, 0.05 per cent or less; and manganese, 1.50-2.00 per cent or more. Theoretically, at least, the basic furnace process can be adapted to use pig irons with widely varying silicon, carbon, phosphorus, and manganese content, but such variations greatly increase the difficulties of control of the steel-making process and we find an increasing demand for constancy of composition in the pig iron supplied to the open-hearth shops. Many operators also firmly believe that wide variations in the suitability of pig iron for making good steel exist, which are entirely independent of the variations in the ordinary analysis. Although the effects here are doubtless often exaggerated, the belief is common enough to have caused the Open-Hearth Committee of the American Institute of Mining and Metallurgical Engineers to appoint a committee to study the problem, which may be solved during the current year (1927).

For many years, plants in Germany and elsewhere have been using higher manganese pig irons, with analyses of 2, 3, or even 4 per cent manganese. In the last few years a tendency to favor high-manganese iron has been noticeable in American shops, and we are only lately beginning to learn the causes for certain beneficial effects of manganese in an open-hearth charge. One rather striking effect of manganese in pig iron was shown by Herty and Gaines,[11] who studied the drop in sulphur content occurring in the interval between tapping various casts at the blast furnace and charging to the open hearth from the mixer. These decreases were widely variable, depending upon the initial sulphur content at the blast furnace, but the final sulphur contents at the open hearth were quite regular, decreasing with increasing manganese, and could all be expressed quite closely by the relation:

$$(\text{Per cent Mn})\ (\text{Per cent S}) = 0.70.$$

With manganese contents above 1.50 per cent, if the iron is freed of all slag at the blast furnace, the iron delivered to the open hearth will nearly always have a sulphur content below 0.05 per cent. As to the causes of this desulphurizing action, it is found (1) that relative to FeS, MnS has a very small solubility in molten iron; and (2) that the decrease in temperature after the iron leaves the blast furnace probably favors the formation of MnS and also decreases its solubility in the iron. This desulphurizing effect of manganese may become of increasing importance in the future if available blast-furnace cokes increase in sulphur content.

Open-Hearth Reactions and Equilibria.

As the result of the work of such men as Colclough[14b] and McCance[14a] in England, and of Field[14d] and Herty[9] in America we are beginning to obtain some definite data on the physical chemistry of open-hearth reactions and of steel making in general. Although a beginning has been made, this work is very much handicapped and limited by the lack of data relating to the properties of the metals and oxides at steel-making temperatures. The constitution, viscosities, etc., of liquid open-hearth slags, heats of reactions, specific heats, solubilities of FeO and MnO in molten steel, dissociation constants, etc., are among the important data badly needed in steel-making chemistry, but they are gradually being obtained. Especially promising in this field are the systematic researches on the physical chemistry of steel-making which are being carried forward under the direction of W. Rosenhain at the National Physical Laboratory in England and of C. H. Herty, Jr., at the Pittsburgh Experiment Station of the U. S. Bureau of Mines in America.

Gas Oxidation.

Herty[5] has determined the amount of FeO formed during the melting period in the open hearth when surfaces of melting scrap are exposed to the oxidizing gases. In one heat with very large scrap used, the FeO formed amounted to 1.76 pounds of FeO per 100 pounds of scrap; and in two other comparable heats, but with medium sized scrap, 9.35 pounds of FeO was formed per 100 pounds of scrap. Oxidation during melting is thus apparently proportional to (1) area of exposed surfaces of scrap, (2) time of melting, and (3) probably also to the type of flame, gas composition, etc.

After the slag has formed, oxygen is carried through the slag layer from gases to steel by Fe_2O_3, according to the following reaction, as demonstrated by Whitely[14c] and others:

$$Fe_2O_3 + Fe = 3FeO;$$

the Fe_2O_3 is formed continuously at the upper slag surface by the oxidizing gases. Colclough[14b] has shown that the concentration of Fe_2O_3 tends to increase with increase in the lime content of a slag. This he attributes to the formation of a stable spinelloid of the composition $X\ CaO.Fe_2O_3$, which has been identified in solid slags.

The actual oxidation of the impurities in the steel is accomplished largely by FeO in solution in the bath of metal. The maximum solubility of FeO in pure liquid iron under a pure iron oxide slag is known to be about 0.94 per cent at the melting point. This solubility increases by superheating above the melting point, but we do not yet know the rate of increase in solubility with temperatures above 2790 deg. F. Under complex open-hearth slags the solubility of FeO in the bath is always below the maximum solubility, and varies with the percentage of iron oxides in the slag.

The pressure of other metals like aluminum, manganese or silicon in the bath reduces the solubility of FeO, and this effect may be considered as the essential mechanism of deoxidation. A small percentage of aluminum reduces this solubility almost to zero; silicon and manganese lower the solubility to values varying with the percentage of Si or Mn remaining in the metal; silicon has the most powerful deoxidizing effect. MnO also seems to have a small, but appreciable solubility in iron, which has not been determined. McCance[14a] has calculated quantitatively the "deoxidizing power" of varying amounts of manganese and silicon at different temperatures, but his results probably should not be accepted without reserve until more evidence is obtained from direct measurements.

In steel, where carbon is present oxygen appears also to be dissolved in the form of CO, most of which is evolved from the metal during freezing. This solubility probably increases with the temperature and the concentration of FeO and decreases with increased amounts of the deoxidizing metals, aluminum, manganese and silicon. Very few quantitative data on the solubility of CO are available, however. It is obvious that data giving the solubilities of FeO, MnO, and CO under various conditions are fundamental to an exact understanding of the process of deoxidation and degasification or "killing" of steel, and are data very much to be desired. For example: The process of making rimmed steel depends essentially upon pouring the steel into the ingot mold with just about the right amount of CO gas in solution to give the desired amount of boiling action during freezing of the metal and give a good rimmed ingot with a fairly thick solid skin and not too many gas holes in the center portion. Even a small amount of silicon leaves too little dissolved CO gas to make rimmed ingots, while much more manganese may be present and still allow the rimming action to proceed properly. Rimming heats are accordingly tapped with but a trace of silicon present, and ferromanganese only is added in the ladle.

Sulphur Absorption and Elimination.

The studies of Herty[13],[16] and associates indicates a picture of continuous approach to equilibrium in sulphur exchange between gases and bath during the whole open-hearth heat. During melting, surfaces of steel scrap are exposed to contact with the gas stream and sulphur is exchanged between them according to one or both of the following reactions:

(1) $SO_2 + 2Fe \leftrightarrows FeS + FeO$; or

(2) $3SO_2 + 7Fe \rightleftarrows 3FeS + 2Fe_2O_3$.

If the gases are almost free of SO_2, the scrap will be desulphurized, but ordinarily the balance is thrown in the opposite direction and the steel steadily absorbs sulphur during melting The exchange occurs largely after the scrap has begun to melt, sulphur being lost or absorbed through the liquid film of oxide on the scrap surfaces.

After the slag is formed on the bath, there is a balance formed again between sulphur in the gas as SO_2 and sulphur in the liquid slag, probably as CaS. Herty gives the following probable reactions for this interchange:

(1) $SO_2 + 3CO + CaO \rightleftarrows CaS + 3CO_2$; or

(2) $SO_2 + CaO + 3Fe \rightleftarrows CaS + 3FeO$.

Conditions are favorable here for a close approach to equilibrium conditions and the concentrations of sulphur are low in both phases. They seem to vary with each other according to the simple distribution law, the ratio being expressed by

$$\frac{\text{Volume per cent } SO_2 \text{ in gas}}{\text{Per cent S in slag}} = 0.270$$

as given by Herty,[13] who also found that under ordinary furnace conditions, the balance here would exist with the percentage of SO_2 in the combustion gases at about 0.35-0.40. If natural gas is used as fuel, the gases always absorb sulphur from the slag, and the same usually hold for tar or oil fuels with sulphur below 0.5 per cent; but if producer gas, coke-oven gas, or high-sulphur oils are used, the slag absorbs sulphur from the gases, so that de-sulphurization of the metal is retarded proportionately. Herty also indicates by calculations that it should pay to purify coke-oven gas down to about 100-135 grains of S per 100 cu. ft., especially where the sulphur content in the pig iron used tends to approach 0.07-0.08 per cent. Sperr[3] has described a process for desulphurizing coke-oven gas by scrubbing with dilute soda-ash solutions, which has been installed in one American steel plant.

The exact mechanism of the desulphurizing reactions between slag and metal are not yet well understood. Sulphur is eliminated much more slowly than Mn, C, or P, which are oxidized by FeO in solution in the steel. Sulphur as FeS is apparently not oxidized by FeO in the steel at the low concentration of S usually present, while a high FeO concentration in the slag tends to retard desulphurization This reaction seems to occur only at the slag-metal interface, perhaps by interaction between CaO and either MnS or FeS to form CaS in the slag. The conditions favorable for sulphur elimination—that is, low FeO and high free lime concentrations in the slag—are to a large extent opposing factors in the elimination of the other metalloids and manganese. Colclough[14b] gives curves showing simultaneous variations in sulphur and manganese contents which indicate that sulphur is eliminated rapidly only when conditions are such (high lime and low FeO in the slag) that manganese is being reduced from the slag. He expresses the opinion that manganese sulphide is the only active agent in desulphurization; but this is still very uncertain. Higher manganese contents make it possible to keep a fluid slag, yet one highly basic and low in FeO, which conditions are all favorable for reaction between FeS and slag at the slag-metal interface, so that manganese may have an indirect rather than a direct effect in desulphurization.

Mangenes Reactions: Equilibria.

The reactions involving manganese in the open hearth are given by Herty[9] as follows:

(1) $Mn + FeO \rightleftarrows MnO + Fe$, and

(2) $xMnO + SiO_2 \rightleftarrows xMnO.SiO_2$.

In spite of the lack of data on the compounds in an open-hearth slag, solubilities of FeO and MnO in steel, etc., Herty[9] has been able to determine equilibrium constants for reaction, (1) from which, knowing the slag composition and temperature, the residual manganese in the steel can be closely determined by calculation, if the P_2O_5 content of the slag is less than 5 per cent. This is good evidence that the reactions approach true equilibrium conditions in ordinary working and is also rather striking evidence of our increased quantitative knowledge of such high temperature reactions. The concentrations of FeO and MnO in the metal are not known, but according to the partition laws must have a constant relation to the concentration of FeO and MnO in the slag, and the latter are used in determining the equilibrium constants. Such equilibrium calculations can be made only when the manganese content of the bath is not changing rapidly and when no "false equilibrium" is caused by a high slag viscosity. If slag is high in CaO or MgO and low in SiO_2 or MnO it often becomes so thick and viscous that its constituents have too little mobility to react with the liquid steel and certain reactions may be almost stopped, but will start again if the slag is thinned with fluorspar.

The tendency towards higher manganese pig irons in American practice has been mentioned above, together with the desulphurizing effect on the pig iron of high manganese. Higher manganese charges for the open-hearth are also beneficial by (1) making fluid slags with little or no spar additions and, (2) by increasing the residual manganese contents so that less manganese needs to be added when tapping, and, under certain conditions, somewhat cleaner steel results.

During the past year or so there has been a noticeable increase in the production of low-carbon open-hearth steels with manganese content of 1.25 to 2.50 per cent Such "pearlitic" manganese steels may be given mechanical properties fully equal to those of some of the more expensive alloy steels containing nickel, chromium, molybdenum, etc. They are also superior in machining qualities and are good steels for case carburizing. A few companies are also making so-called "guaranteed case-carburizing" steels, using special furnace practice which usually involves the addition of manganese and silicon alloys to the steel in the furnace shortly before tapping

Carbon, Phosphorus, and Silicon Equilibria.

Carbon is oxidized by FeO in the bath according to the reaction

$$C + FeO = CO + Fe$$

but the reaction absorbs heat and is slower than any of the other deoxidizing reactions so that carbon is the last impurity to be removed from the bath and the time necessary to lower the carbon to the desired content usually regulates the length of an open-hearth heat. The equilibrium content of residual carbon is very low and is usually not attained in ordinary practice before the metal is tapped, except perhaps in the production of ingot iron. Complete removal of carbon is prevented only by the small solubility of the reaction product CO in molten iron, and since this solubility is not known, true equilibrium constants cannot be determined for the reaction.

Equilibrium data and calculations for the oxidation of phosphorus have been given by Colclough[14b] and Herty.[9] Phosphorus elimination is tied up closely with certain conditions of viscosity and mineralogical composition of the basic slag, and since there is so very little fundamental data available on open-hearth slags, there is accordingly a great deal yet to be learned about the mechanism of phosphorus removal.

In the basic furnace, silicon is eliminated from the bath very rapidly and the residual content of silicon is usually too small to be accurately measured, so that the reacton in the basic furnace is considered as going to completion. In the acid open-hearth, however, as indicated by McCance[14a] and others, equilibrium conditions are attained with appreciable amounts of residual silicon in the metal and silicon is often reduced from acid slags. This difference between acid and basic processes probably is the main factor tending to produce cleaner steel in the acid open-hearth process.

Conclusion.

Even this brief survey will indicate the rapid progress being made toward complete understanding of causes and effects in the open-hearth process. In conclusion, it is interesting to note a more open and friendly relationship between the open-hearth plants and the men throughout the industry. The most important factors in promoting this change are probably the meetings of the Open-Hearth Committee of the American Institute of Mining and Metallurgical Engineers, for these have been very successful in promoting the free exchange of ideas and a more scientific attitude toward the problems of the open-hearth plant.

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New Merchant Mill Placed in Operation

Layout and Operation of the New 10-in. Morgan Merchant Mill Is Described—Electrical and Mechanical Features Are Particularly Interesting

By CHARLES LONGENECKER

TO the McKinney Steel Company, October 25 of the past year is a date of quite some significance. On that day the new 10-in. Morgan merchant mill was placed on production and the company entered the market as a manufacturer of merchant shapes. Previous to the starting of this mill, the only outlet for the steel produced was the sale of billets and sheet bars.

The history of the McKinney Steel Company contains much of interest, especially that portion covering the early days just after its formation. Like many steel companies, the name has been changed several times, as necessitated by circumstances, but development has been steady and along progressive lines.

Company History.

Some 46 years ago, when the movement of ore over the lakes was receiving much consideration, James Corrigan assembled a fleet of vessels for the transportation of this freight. The intent at that time was only to carry ore, but later developments made the sale of this commodity so attractive that mines were purchased and Mr. Corrigan sold his product in the open market. Unfortunately the panic of 1893 brought financial reverses which so involved the company that a receiver was appointed. The receiver was Mr. Price McKinney, whose surname the company now bears. Under the guidance of Mr. McKinney, the company prospered and expanded. Blast furnaces were leased, or purchased, and pig iron was marketed until 1916, when open hearth furnaces were placed in operation and the iron was converted into steel. At this same time a 40-in. blooming mill was put in service, affording the company the opportunity to enter the market as a seller of billets. Since 1916 other additions have been made to the plant equipment so that today the company produces its own coke from 204 by-product ovens, its own pig iron from four 600-ton blast furnaces, and its own steel from fourteen 110-ton open hearth furnaces. Thus the raw products, ore and coal, are received from mines owned by the company and converted into marketable products, such as billets, sheet bars, rounds, flats, skelp, etc. At the present time a 12-in. merchant mill is being

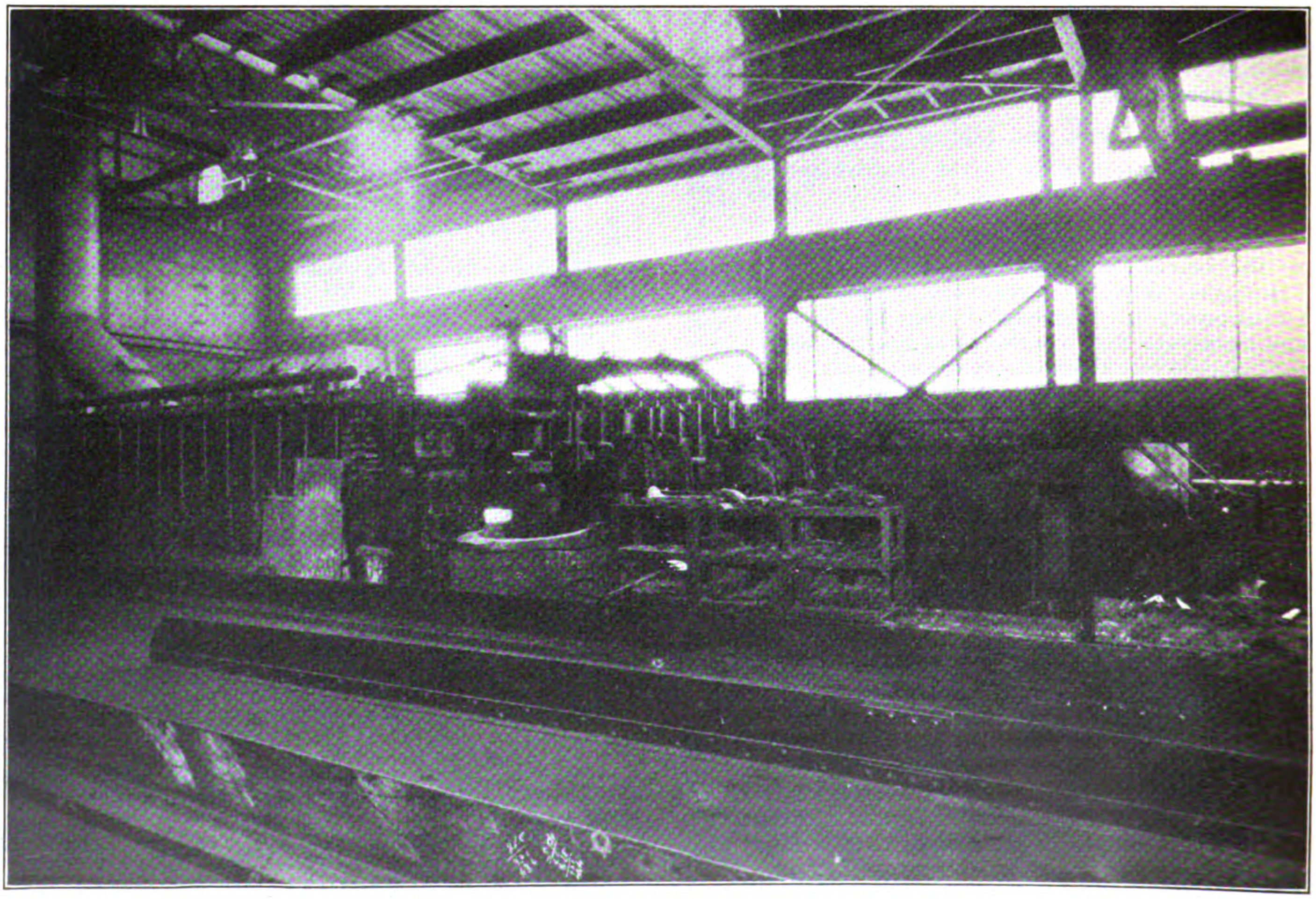

FIG. 1—Continuous furnace and roughing rolls.

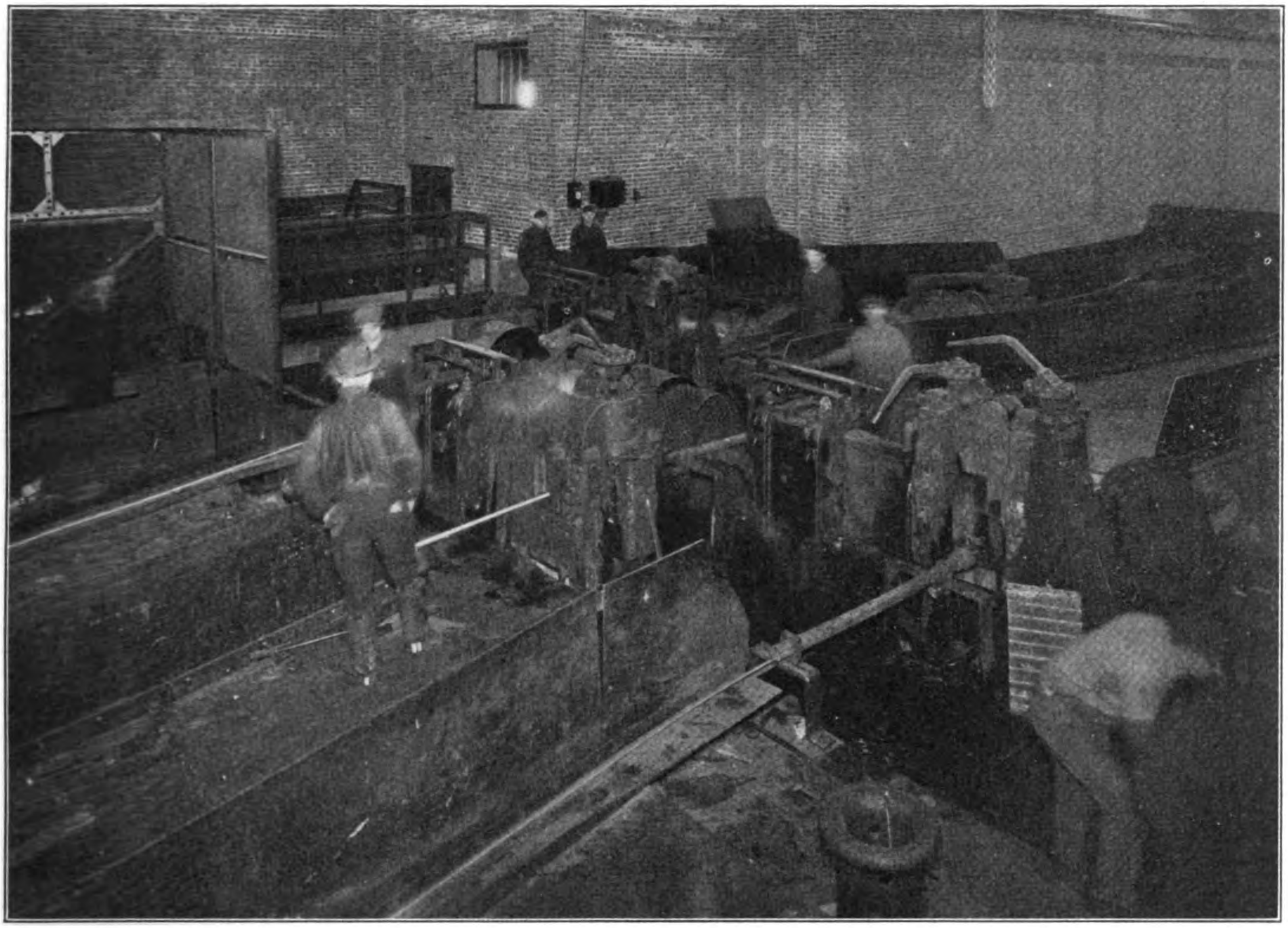

FIG. 2—Three stands of intermediate rolls.

erected, and will have a capacity of 20,000 tons per month. The product will be rounds from 5/8 in. to 3½ in., flats up to 8 in. wide and squares 5/8 in. to 3 in.

Mill Characteristics.

The 10-in. mill has an output of 10,000 gross tons per month, made up of rounds, flats, squares or skelp.

The outstanding characteristic of this mill, from the discharge floor of the furnace to the loading platform, is flexibility. Roll changes can be made quickly, changes in form, say, from squares to skelp, can be accomplished with very little loss of time, and labor requirements are held to a minimum.

The billets, from which the shapes are rolled, vary from 1½ in. to 3 in. square. These are received on a conveyor at the charging end of a "side charged" Morgan continuous furnace. This furnace is fired by producer gas which is generated in two producers located in the same building and near the furnace, so that the gas is delivered to the furnace hot. The furnace is of the Morgan pattern with a recuperator. After progressing the length of the furnace hearth, the heated billets are discharged by a Hawthorne pushout and enter the roughing rolls. An ingeneous method of breaking the scale from the billets, as they emerge from the furnace, is through the use of two rolls with milled surfaces. The billet, after passing between these rolls, is practically free from scale. As the billet approaches the rolls the end is sheared and thus a square, clean surface comes in contact with the pass in the rolls.

The roughing rolls are arranged in two groups of four stands, so placed that a distance of about 20 feet intervenes between the fourth and fifth stands. In traveling this distance, the piece rests on rollers which are driven by individual motors. This feature is of significance in that the replacement of a roller is readily effected as both the roller and motor can be quickly removed and replaced by another unit. Fig. 1 shows the furnace together with the first stand of rolls. In the first four stands the rolls are 14-in., while those in the second group are 12-in. The eight stands are placed in a line so that the billet travels direct from the furnace door.

After passing through the roughing rolls the piece is delivered to the first stand of the three intermediate rolls and is then looped through these to the finishing stand. In Fig. 2 is shown the intermediate stands with a partially rolled billet passing through the rolls. Ample protection is afforded the roll crew by various safety devices installed on the rolling floor. Roll speed has been calculated to avoid particularly long loops. The tandem construction has been followed in locating the finishing stands into which the piece is directed on completion of the intermediate rolling.

Electrical Drives.

One of the most impressive features in the construction of this mill is the attention that has been given the electrical equipment necessary for the drives, etc. All motors and other accessories are housed in rooms adjacent to the mill, with no connection thereto other than those openings in the walls through which the driving shafts pass.

The power for driving the mills is generated in a power plant operated by the company. Blast furnace gas burned under Stirling boilers creates the steam which is ultimately converted into 6600-volt, 25-cycle alternating current. This current is transformed by two 2,500-kw. generator sets, from alternating into direct, at 600 volts and as such is delivered to the motors. To drive the roughing rolls a motor of 1,000 hp., operating at a speed of 200 to 600 rpm., has been provided. This motor, while of 1,000-hp. capacity, is in reality formed by mounting two compensating 500-hp. compound motors on a single bed plate. A 2,000-hp. motor, operating at a speed of 137 to 275 rpm., drives the intermediate rolls, while the finishing rolls are connected to a motor of 1,200 hp. with a speed of 300 to 500 rpm. Controls are of the magnetic panel type. The operation of the various drives is controlled from an elevated platform located to the right of the intermediate rolls. From this platform all movements throughout the mill are visible to the operator.

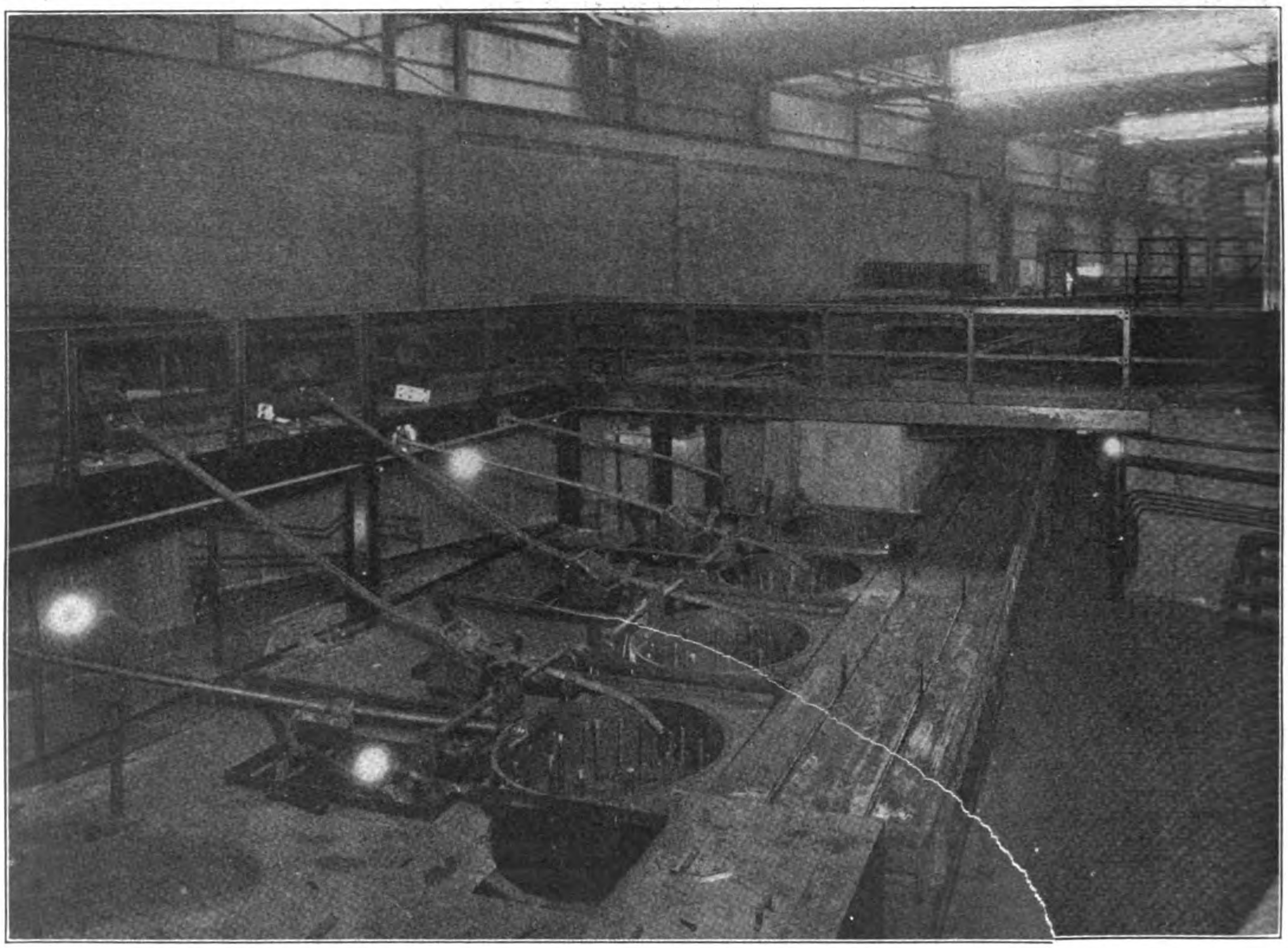

FIG. 4—Pouring reels with discharge conveyor.

From the finishing rolls the piece can pass direct to the cooling bed, to the pouring reels or to the ribbon reels. The pouring reels will receive rounds from ¼ in. to ⅞ in., squares ¼ in. to ¾ in. in size or nut flats of equivalent cross section. Strips from ⅞ in. to .04 in. or from 2½ in. to .06 in. can be handled on the ribbon reels.

Reeling Equipment.

Fig. 2 plainly illustrates the location and construction of the pouring reels. As there are four reels the section on leaving the finishing rolls must be directed to one of these. This is accomplished by appropriate mechanism, which guides the rod into one of the four pipes leading to the reels, each of which, with its motor, can be operated independently. Control of this mechanism is effected by an attendant. When the light round (or square) reaches the reel it is wound on the fingers until the coil is complete. The bottom plate is then raised and the coil pushed off onto the conveyor on which it travels to the loading platform. To reach this platform the conveyor must pass under the approach to the cooling bed and then rise to a higher level. At the point where the conveyor terminates the coil is picked up by a hook, suspended from an endless traveling chain, and delivered to cars standing on the loading track.

The "ribbon" reels are located beyond the "pouring," but on the same side of the cooling bed. These reels operate in a manner similar to those just described. In a like manner also the coils are pushed onto a conveyor. Both the conveyor from the pouring and from the ribbon reels has a covering formed of water-cooled cast iron plates, which materially assists in reducing the temperature of the coils as they pass along to the point of discharge. Between the last stand of the finishing rolls and the table, leading to the ribbon reels, a vibrating mechanism is placed through which the strip must pass on edge. This vibrator whips the light strip back and forth in such a manner that it moves it in the form of waves so that its progress to the reels is naturally slower than would be the case if the strip was straight and moved in a direct line. The slow approach of the strip gives the operator at the reel time to shear and hook the end to the reel. A time element is thus introduced which assists materially in economic operation.

Cooling Beds.

When the schedule calls for material to be delivered to the cooling beds, it passes direct from the finishing rolls to the approach table. Each roller in this table is driven by an individual motor direct connected. From the roller table the section passes the length of the cooling bed over conical rollers. On leaving these rollers it is moved over the bed to a conveyor which carries it to the shear. The blades in this shear are easily changed to conform to the shape being cut. To assure shearing to correct length, gage blocks are mounted beyond the shear. Three of these blocks are provided to facilitate rapid and easy adjustment. The sheared length is tripped into a bundling rack from which it is removed to a car, or placed in stock.

Progress in the Blast Furnace Field

The Author Outlines the Progress That Has Been Made This Past Year in Improving Practice in Blast Furnace Operation and Points Out Trend for Further Betterment

By F. H. WILCOX*

THE trend of practice and equipment in the blast furnace field during 1926 has developed little departure from the course observed over the preceding three years. The large hearth and large capacity furnace has continued to show exceptional tonnage and cost above materials figures, even if coke consumption rates and net metallic losses have not been as satisfactorily brought down. Probably furnaces of the 21,000-25,000 cu. ft. class continue to make better showings in coke and loss than do the furnaces in excess of 25,000 cu. ft.

Nevertheless, the advantages of the large furnace are, in stable times, sufficient and definite. They are correct adjuncts of large steel works. They must not necessarily be the correct adjunct of moderate size steel works. For one reason, there is, of course, a tremendous tonnage loss to be made up when one furnace is out. For another reason, large furnaces have yet to prove as flexible in tonnage output on good quality iron as are the moderate size furnaces, and therefore may not prove as adaptable to fluctuating demands in unstable market conditions.

Tendency Toward Larger Tuyere Area.

Detail developments in furnaces seem to be a tendency toward a larger tuyere area relative to bosh area, caution in further decrease of bosh height or increase of bosh angle, increase in area of stock line, and stationary inwall batter. Inwall cooling is increasingly used, removable cooling plates being in favor. Refractory nose tuyeres are being adopted both as regular or emergency equipment, particularly with small coke. Petticoat jackets, or modifications thereof, are being used with good success in the east and south.

Much the same development in furnace size and line is progressing abroad, and tonnages of better than 1,000 tons a day per furnace are this year on record on both sides of the Atlantic. Some mention is heard of projected 1,500-ton furnaces.

Considerable research work has been carried on during the year, outstanding and worthwhile results having been achieved by the Federal Bureau of Mines in operation on extremely high alumina slags, and in exploration of the mechanical-physical-chemical relations of distribution, gas velocities, pressures, temperatures and compositions, and reduction equilibria in the upper cross section of furnaces. This is supplementary to the Bureau's results of last year on the lower zones of blast furnaces. It is probable that a measurable revision of opinion in regard to methods of charging, if not furnace design, will follow in due time.

Other noteworthy work has been done by Professor McCaffery and his associates at the University of Wisconsin on mineral constitution of slags. The results have had successful application in practice.

Hot Blast Stove Construction.

Hot blast stove construction has trended toward more conservatism, heating surface being sacrificed for more adequate volume of brickwork, and particularly for stability in service. The increasing use of pressure burners in stove service has had considerable influence on this score, as with the high and severe heat duty thus imposed on stoves, latent defects and weaknesses are brought out in stoves which on moderate heat service had seemingly been quite inadequate. Though this development makes stove cost higher, the advantages of continuity of high heat and good heat reserve give a better return on expenditures for adequate high heat equipment than did expenditures for moderate heat equipment. As high as 400,000 sq. ft. of heating surface is being installed per furnace. A few plants have established exceptional furnace performance on lake ores with 1400 to 1600 deg. F. blast temperature.

An interesting development is taking place abroad, where certain plants are installing special shapes of brick, so-called checker construction being in some cases entirely abandoned. Gas of better than 0.01

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*Vice President, Freyn Engineering Company.

grains cleanliness per cu. ft. is used, the brick shapes are piled in the upper half, practically promiscuously, or in some cases variable checker openings are used, and exceptionally high heats and low stack temperatures are obtained. Two such stoves are used per furnace, on the P. S. S. principle.

Gas Quality Improving.

Here there is a tendency toward better quality gas. Feld washers have been installed at various works and give a wet gas of about 0.09 grains cleanliness. There are also several heat interchangers now in operation. These, in conjunction with Brassert-Mathesius washers, give a dry gas of about 0.15 grains cleanliness, superheated about 50 deg. above gas temperature at exit from washer. The waste gases from the stoves are utilized, the temperature being reduced about 75 deg., thereby materially contributing to all around gas economy. Tests are also in progress on secondary washing supplementary to tower washing. Blast furnace gas is being used, mixed with coke oven gas or unmixed, to extend surplus gas service, in a few steel works.

Stocking and charging equipment installed this year has been, with the exception of one Pittsburgh plant, entirely of the mechanical gate bin type, thereby enabling the furnace to be charged with one man. One installation has been of the modified Hoover roller gate type—the others of the Freyn double gate type. Electric bell operating rigs and stock line recorders have been largely used.

In the power end, this year sees the successful starting in operation of the new design of General Electric turbo blower at two plants, and the operation of several 65,000 cu. ft. Ingersoll-Rand blowers.

Power Equipment Tendencies.

In the boiler house there is a tendency toward high horsepower units, 1200 hp. being a preferred unit. These boilers are capable of high rating, being in one case equipped with economizers, side wall cooling and for simultaneous burning of pulverzed coal and blast furnace gas. High pressures and superheats are increasingly employed, and in two cases the heat balance of the power house and boiler plant is secured by single and double stage bleeding of generator and blower units, electric drive of auxiliaries being increasingly used. Two plants having 10,000 kw. generating capacity were put into blast, the excess output over the furnace requirements being sold to power companies. In total cost per delivered kw., the new blast furnace plants compare rather more than favorably with public service power stations, and a handsome gas credit is obtained, together with a high utilization factor of steam and power equipment installed.

Pig iron disposal is still along conventional lines, with the mixer type ladle finding increasing favor. Slag disposal by means of slag crushing and screening plants is thoroughly established. Slag brick are making little apparent headway. Dry granulation is increasing in use abroad. Flue dust disposal is practically all accomplished by sintering, either through "royalty," "conversion" or owned plants. One coordination of flue dust recovery equipment was put in this year, the dust catcher dust going directly to sintering plant, where it is joined by gas washer dust, the latter recovered through a Dorr thickener and United continuous filter. All dust is handled direct, without intermediary of railroad cars.

Number of Furnaces Steadily Dropping.

During the past four years the average number of furnaces in blast has been held close to 235 to 240, with the total number of furnaces in the country dropping steadily from about 430 to 400. This is the first time in 15 years that any such condition has obtained, except during the war years 1915-1918, inclusive. However, during that period coke and labor was used at any price or quality and in any quantity. Production was forced at the expense of equipment and safety. Plants tottering with decrepitude, so to speak, were prodded into a last effort, illustrated by 84 blast furnaces having been abandoned and scrapped since 1918, their average life being 46 years.

During 15 years the annual output has increased from 25,000,000 to 40,000,000 tons. Except for 750,000 tons in malleable grades, all of the 15,000,000 tons increase has been in steel making grades. Foundry, forge, low phosphorus, silvery and charcoal iron output has been stationary for all intents. Today, 70 per cent of the country's pig iron is made in large works, with the large works' asset of far-seeing management and financial strength, contact with other operating men from different departments, and finally the support of an adequate mechanical and electrical maintenance department.

Continuity of Operation Maintained.

It may not be without interest to review the changes that these 15 years have brought. For one thing, continuity of operation has been maintained, the first time under favorable circumstances for nearly a decade. Second, operating executives have been freed, and again under favorable conditions for the first time in a decade, of the necessity of maintaining and working a large force of common labor for routine operations, its place having been taken by mechanical-electrical handling equipment. Third, rather than the bulk of iron being made at isolated operations, it is made at large operations with every circumstance of support from works management, plant organizations and consultants, and with exact determination of costs, necessary provision for depreciation and replacement, and general expense.

At many plants having the background suggested and the four years constant operating condition to which allusion has been made, remarkable achievements in blast furnace plant design and management have been made. The writer believes this to be the outstanding development, not of 1926, but of the three or four year period just ending, and if outstanding advance in furnace practice and type of construction of plant and auxiliaries has been achieved, it is largely due to stable conditions. With continuation of a stable tonnage, further definite progress and development, sound in character is to be expected, thereby securing increasingly better returns against expenditures for plant capacity.

Early next year the J. Wood department at the Schuylkill Iron Works division of the Alan Wood Iron & Steel Company, Conshohocken, Pa., will be dismantled. The plant built in 1832 by J. Wood & Bros., includes two sheet mills. These will be replaced by modern hot mills for installation at the Schuylkill division.

Car Dumper Electrically Controlled

An Interesting Description of the Modern Car Dumper Is Given in Detail—Both Mechanical and Electrical Features Are Described in Considerable Detail

THE lifting car dumper has for many years been the accepted method of loading coal boats from railroad cars, especially in the coal trade of the Great Lakes. The first dumpers of this type were designed to handle cars of 30 to 50 tons capacity and, by gradual stages, they have increased in size to accommodate the more modern railroad equipment until the present demand is the ability to handle cars having a load capacity of 120 tons of coal with a tare weight of 80,000 lbs.

While electrical operation of car dumpers of other types has developed to a high degree, it is only recently that the adherence to steam operation of direct loading lifting dumpers has wavered and full electric operation has been adopted

The first electric lifting car dumper of this type was installed at Baltimore in 1920 and is owned by the Western Maryland Railway Company. The next installation was in the past year 1926 at Toledo, Ohio, on the docks of the New York Central Railway Company, Ohio Central Lines. The Toledo car dumper, which is the subject of this article, has many features which depart widely from past practice in lifting car dumper construction.

This machine is designed to handle all sizes of open top railroad cars ranging in size from the smallest to the largest, 120 ton capacity, at a rate of 40 cars per hour, was placed in operation about April 1, and approximately 2,225,000 tons of coal were handled by August 1, which is considered a record performance.

For the first time in the history of car dumper construction, generator field (Ward Leonard) control is used for the operation of the mule haulage and cradle hoist functions. This method will be further described later. The auxiliary functions are operated by rheostatic control. All power is d.c. at a potential of 250 volts.

Dumper Construction.

Essentially the car dumper consists of a main supporting structure carrying a lifting cradle, a pan girder, an adjustable pan into which the coal is dumped from the railroad car; a telescope chute at the outer end of the pan, through which the coal passes from the pan into the hold of ship; the machinery units for the different operations, and the sub-station units. The main structure is located adjacent to the dock face with the pan overhanging the boat. The pan is hinged to the pan girder which is capable of vertical adjustment in height to accommodate different heights of boats. The inner end of the pan is wide enough to

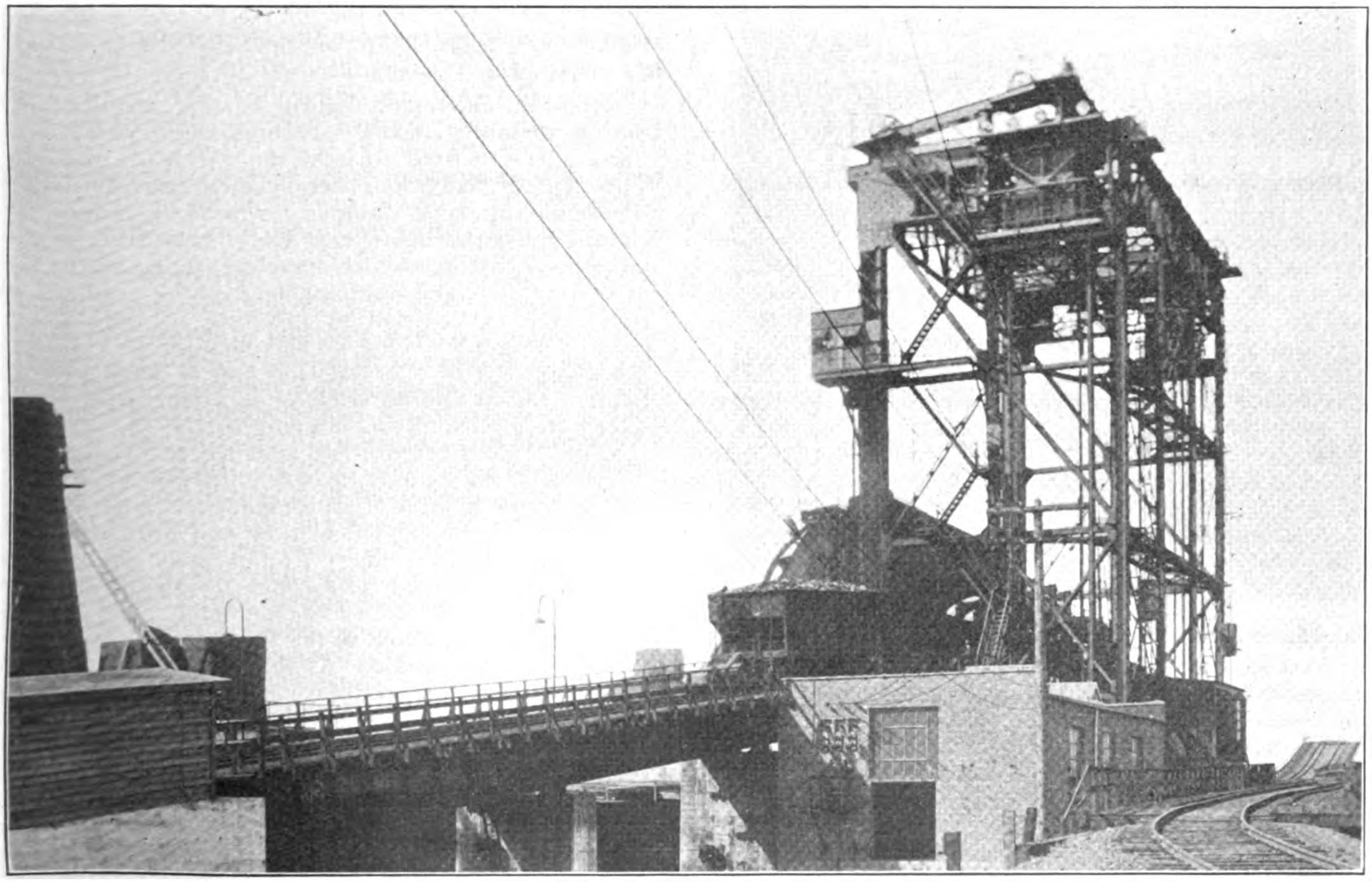

FIG. 1—View from empty car track showing loaded cars approaching 120-ton lifting dumper.

receive coal dumped from the longest cars, but is contracted to a narrow outlet at the discharge end where the telescopic chute is attached. The outer end of the pan is supported by ropes leading over the top of the structure to the pan hoist drum. By this means the pan may be hoisted to clear the passage of boats when out of service.

The telescopic chute is hinged at the outlet of the pan and consists of four sections which may be drawn up or extended as desired, to meet the loading conditions. This chute is also capable of swinging in a vertical plane at right angles to the dock so that coal may be discharged in board or outboard of the ship and thus properly trimmed A trimmer is applied to the lower end of the chute and so arranged that it may be rotated about the axis of the chute, thus giving control of the direction of coal discharge.

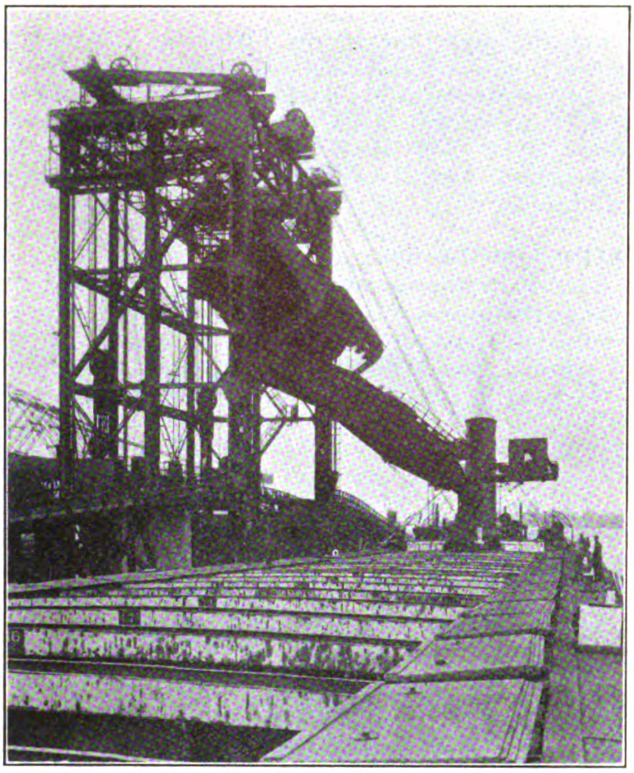

FIG. 2—Front view from boat showing cradle inverted.

The car tracks in the cradle are elevated about 25 ft. above the dock and cars are entered into the dumper by means of a mule which is operated by a haulage cable and pushes the cars up a 12 per cent approach grade leading from the dock level to the elevated position of the cradle. The mule travels on a narrow gauge track between the rails of the standard gauge track over which the railroad cars travel up the approach.

Car Movement.

At a suitable point in the approach a by-pass gate is installed and a depressed narrow gauge track is provided so that the mule in returning down grade may travel under a car standing at the bottom of the grade. When the mule is started to push the loaded car up the grade it passes over another by-pass gate back of the loaded car and runs on a track at the same elevation as the car track, a push bar on the mule engages the back coupler of the car, pushing it up the grade into the cradle of the dumper.

After the car has been dumped it is bumped out of the cradle by the next loaded car after which it travels by gravity down an inclined run off track to a kick-back and thence, still by gravity, down inclined tracks into the storage yard for empty cars.

The main structure of the machine is approximately 108 ft. high, the front and back columns are 36 ft.-0 in. center to center and the front columns are 70 ft. centers, giving a dumping clearance of 64 ft. The platen rails are 25 ft. above the foundation. The pan is approximately 64 ft. long at the inner end and contracts to about 5 ft. at the discharge end. The inclined length of the pan from the girder hinge to the chute hinge is 43 ft. The pan girder has a vertical range of 24 ft. from the lowest to the highest position. The telescope chute when contracted is 13 ft. below the chute hinge and can be extended to 28 feet.

Departing from previous construction the pan girder is designed to travel on the front face of the front column, the adjusting screws are carried on brackets on the face of these columns where any danger of damage from car interference is eliminated. This construction is much simpler than the previous method and greatly facilitates repairs.

Another feature is the over counterbalancing of the cradle. This is so arranged that the necessary power required to hoist a loaded car is practically the same as the power required to pull the cradle and empty car down after dumping. This has the effect of greatly reducing the power required for the cradle operation and effectively reducing the peak loads which occur during the cycle.

Two drums are used for the cradle hoist ropes and these ropes are so arranged that each drum has ropes leading to both ends of the cradle. In case a drum shaft or gear should fail the cradle can not fall as it would be held by ropes to the other drum.

Car Clamping Device.

Another important feature of this installation is the car clamping device. Pivoted counterweights on the cradle are used to hold the car while dumping. This type of clamp has been very extensively used on the revolving type dumper for several years. The clamps consist of heavy cast steel beams supported by large hook castings which travel in guides on the back of the cradle. The dumping face of the cradle is entirely free of obstruction resulting in free flow of coal. The guides being on the back of the cradle are not clogged with material, and can be kept well lubricated, thus avoiding sticking so common to clamps which are guided at the dumping side of the cradle.

The counterweights are attached to pivoted arms which hold the clamps up when the cradle is seated. As the cradle is lifted from its seat the clamps descend to the top of the car where they rest until the cradle has rotated about 50 deg At this point the counterweight arms automatically connect with the clamping cables holding the car while dumping and until the empty car has returned to the 50 deg. point when they release the clamp cables. As the cradle approaches the initial position the counterweights are deflected by inclined guides and raise the clamps off of the car. As the clamping device is self contained on the cradle no outside counterweights are required, resulting in a much simpler structure as none of the usual guides are required.

The space below the cradle surrounded by the columns of the main structure forms the machinery house where the cradle hoist and mule haulage machinery is located. The pan hoist machinery is in a separate house at the back of the machine directly above the cradle hoist drums while the motor for operating the pan girder screws is located at the front of the machine on an open platform.

Operation of Machine.

Due to the extreme accuracy of electric control and the introduction of automatic features, only two operators are required to operate this machine; one located at an elevated station on the main column and the other at the outer end of the pan over the boat. The first controls all of the operations of the mule and cradle while the second operates the chute and pan.

The mule haulage is equipped with limit switches providing acceleration of the mule out of the pit; slow down to engage the loaded car, acceleration after the car is engaged and slow down and final stop at the top of the grade. An interlock with the cradle operates to stop the mule near the top of the grade unless the cradle is in position to receive the car. On the return mule cycle the automatic switches accelerate the mule down grade, slow up to enter upper by-pass gate, accelerate, and slow down and stop mule in lower pit. The mechanism for operating the by-pass gates is located at the upper gate and is so interlocked with the mule haluage mechanism that the upper and lower gates are always in the proper position.

All of the above operation is automatic, requiring no attention of the operator, although the control is so arranged that the operator can control it manually with a separate throwover switch.

The operation of the cradle involves first a vertical lift and then a turning motion. The cradle is held in a vertical position while lifting by means of cross heads which travel in guides in the main columns and by rollers engaging the columns near the bottom of the cradle. The adjustable pan girder is provided with heavy hooks which engage pivot pins on the cradle at the completion of the vertical lift. As soon as the pivot pins engage these hooks the cradle starts to rotate about the cross head, at which time the rollers on the cradle leave contact with the columns.

Automatic Features.

The automatic features of the cradle hoist are controlled by a traveling nut type limit switch and include acceleration and slow down to engage the hooks; accelerating on turn over and final slow down and stop to dump; acceleration in the reverse direction; slow down to disengage hooks; lowering acceleration slow down and final stop. On account of the fact that the slow down and final stop in seating the cradle always occur at the same place the limits are placed in a fixed position on the structure. The automatic functions around the pivot pin, however, are required to operate with the pan girder in any position. This variation is adjusted automatically by a differential gear device which is connected by gearing to the cradle hoist and pan girder screw mechanism. When the pan girder is moved it advances or retracts the traveling nuts in the limit switch so that they will function properly when the cradle is hoisted into the hooks.

The hoisting mechanism for operating the cradle consists of two heavy cast steel drums geared to a single pinion on an intermediate shaft between the drums. The bearings for the drum and the intermediate shafts are mounted on a heavy cast steel bed plate secured to the foundation. The pinion shaft is extended to take the motor gear which is of double helical type and meshes with two motor pinions, which are connected to the hoist motors by flexible couplings. The intermediate shaft is provided with a manually operated emergency brake and each motor has an electrically operated service brake which sets as soon as the current is cut off the motor.

The axes of the drums are at right angles to the face of the dock and ropes from each drum lead to the opposite ends of the machine. The counterweight ropes are attached to the drums opposite to the hoist ropes and unwind as the cradle is hoisted, the counterweights assisting the motors in revolving the drums, thus cutting down the peak loads on the motors.

Size of Motors.

The cradle hoist motors are 450 hp. each and are driven by separate d.c. generators located in the substation building at the end of the dumper. These motors are controlled by adjustment of the generator fields by magnetic controllers operated from the cab by a small master switch.

The mule haulage rope is wound on a drum provided with a single herringbone gear which meshes with two driving pinions. Each of these pinions is connected by a flexible coupling to a 450-hp. d.c. motor. Manually operated emergency brakes are provided outside of the flexible couplings and each motor is provided with an electrically operated service brake. The mule haulage motors are driven by separate d.c. generators in the same manner as the cradle hoist motors.

The pan hoist mechanism is carried on an elevated platform in the rear of the main structure above the cradle hoist drums. This mechanism consists of a drum geared by two reductions of spur gearing to a 295-hp. mill type motor, provided with rheostatic control operated by a master switch in each of the two operator cabs. Either of these switches may be used to operate this mechanism, but only one at a time. This mechanism is provided with an electrically operated service brake on the motor and with a solenoid emergency brake operated from either cab and so arranged that the emergency brake must release

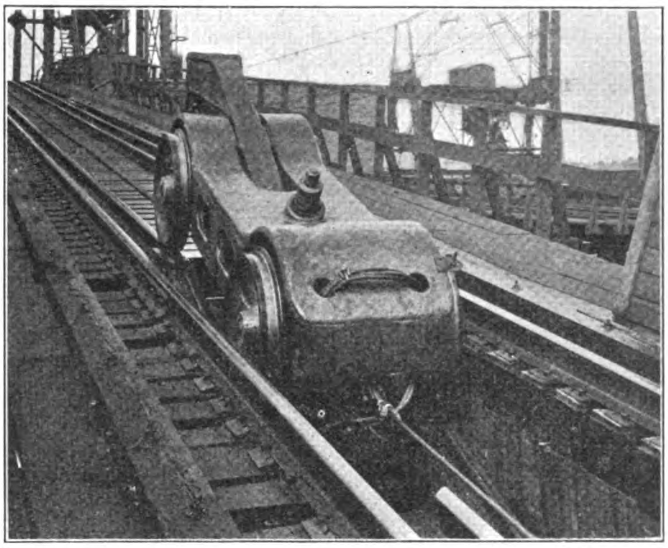

FIG. 3—Mule returning to pit entering upper gate.

before the service brake releases either in raising or lowering the pan.

Rating of Motors.

All motors are wound for 150 volts d.c. and are rated as follows:

Cradle hoist	2–450 hp.
Mule haulage	2–450 hp.
Pan hoist	1–295 hp.
Screw	1–105 hp.
Chute	2– 45 hp.
Gates	1– 13 hp.

The substation equipment is located in a separate station at the incoming end of the machine and includes three identical generating units; together with the a.c. and d.c. switch boards, meters, etc.

Each of the power units consists of two 375 kw., 250 volt d.c. generators direct connected to a single 1100-kva. synchronous motor operated on a 6600-volt, 3-phase, 60-cycle current. One of these units is used for operating the cradle hoist and one for the mule haulage. One of the generators of the third set is used for motor field excitation for the synchronous and d.c. motors as well as for the operation of the d.c. auxiliaries. The second generator is a spare which can be connected in series with the exciter, to supply power at 500 volts if desired.

The control of the cradle hoist and the mule haulage are identical in principle and is the well known Ward-Leonard system. The two cradle hoist motors, for instance, have their armatures electrically tied together by a loop circuit of heavy copper This loop is permanently connected at all times except in case of emergency.

The speed and direction of the cradle hoist motors is governed by the value and direction of the generator field current, the field of the motors remaining constant on a given direction of operation. In this way, while the energy applied to the cradle motors may reach peaks amounting to probably 3500 amperes at 500 volts under normal operating conditions, the generator field will never be in excess of 28 amperes at 250 volts and as the generator field only is controlled the equipment is thus reduced to small capacity units.

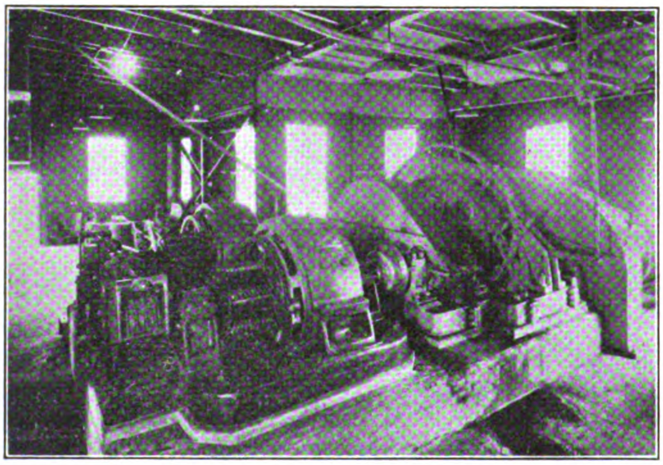

FIG. 4—Two 450-hp., 250-volt motors and solenoid brakes operating in series with generator field control and cradle hoist of 120-ton lifting car dumper.

When a small amount of excitation is applied to the generator field a current is induced in the armature loop circuit, producing a torque at the motor depending upon the value of the current. Current and torque will increase to a point where the motor armature will begin to rotate and generate a counter emf. which tends to reduce the loop current. This condition quickly reaches a point of equilibrium where only enough current flows to produce the necessary torque to overcome the resistance of the drive, and the motor will rotate only fast enough to produce the proper counter emf. to hold the loop current at its proper value.

Manipulation.

It is apparent that by manipulation of the generator field excitation, which is very small and easily handled, the rotating speed of the motor can be very accurately controlled, and that the speed is practically independent of the load. Reverse direction is obtained by simply reversing the generator field current which in turn reverses the current in the armature loop, without disturbing the motor fields.

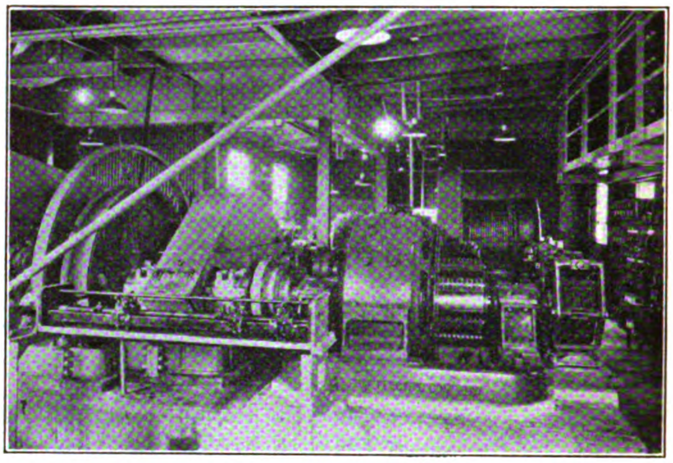

FIG. 5—Side view of cradle hoist drive showing limit switch with differential connection to girder screw.

The simplicity of operation and accuracy of control recommend electrical operation for lifting car dumpers where the fundamental functions are considerably involved, and where automatic regulation may be obtained by electrical devices. In the absence of such features the successful operation of a car dumper is, to a large extent, dependent upon the skill of the operator, and this element is practically eliminated by electrical operations.

By no means the least important consideration is the economy of power consumption attained by electrical operation. Although extensive calculations have indicated theoretically that great economies could be secured by Ward-Leonard control and proper counterbalancing methods, it was the actual operation of this equipment which positively demonstrated the great economies possible. Records of this operation show a power consumption of approximately .27 kwhr. per ton of coal handled which is a small fraction of the cost of steam operation.

The Shenango Furnace Company, Sharpsville, Pa., will proceed with the early construction of a new one-story addition to its plant, to be used primarily for the production of ingot molds, estimated to cost in excess of $500,000, with machinery. W. P. Snyder, Jr., is president. Headquarters are in the Oliver Building, Pittsburgh, Pa.

British and European Industrial Conditions

Existing Conditions in Great Britain and the Continent Discussed by an English Author—The Operation and Limitations of the Recently Formed Cartel Are Featured

By A. C. BLACKALL

IN my 1925 review of conditions in the British iron and steel industry for The Blast Furnace and Steel Plant, I stated that, "There are fortunately, however, now indications of a steady all around revival." And in proof of that contention, a certain general all around improvement was noticeable with the advent of 1926. This state of affairs unfortunately received its quietus early. Hopes were laid low with the Great General Strike and were entirely dispelled with the coal strike, which, up until the time of writing still remained unsettled, although generally conceded to be virtually over.

The effects of the strike have been keenly felt all over the country, and the figures in connection with the iron and steel trade of Teeside may be taken as practically typical of all producing centers. On the north east coast 38 blast furnaces were in operation on April 30 last, and the production of pig iron during that month amounted to 167,000 tons. Since that time production has steadily fallen off as shown in the following table:

	1925		1926	
	Furnaces working	Output tons	Furnaces working	Output tons
April	38	170,600	38	167,600
May	38	168,700	7	24,000
June	36	158,800	4	16,000
July	35	152,400	4	11,000
August	34	143,500	4	*10 000
September	32	136,600	4	*10,000
October	34	139,400	..	......

*Estimated.

In the opening months of this year there was a definite increase in the production of iron and steel, and there was every prospect that the industry was in for a period of improved trade. During the first four months of the year the shipments of iron and steel by rail from the north-east coast area showed an increase over the 1925 figures for the same period of 15 per cent. In the same period the shipments of manufactured iron and steel from the Tees increased over 22 per cent.

Production in England.

In a recent speech discussing the steel industry, the Home Secretary, Sir William Joynson Hicks, gave some illuminating figures. He said that, whereas in 1913 there were 338 blast furnaces going in this country, in September last there were only five. From January to December, 1925, the output of pig iron was 4,750,000 tons. Over the corresponding period this year the output was 2,500,000 tons. France, Germany, and Belgium had all been profiting during the last few months at our expense. In April of this year we produced in this country 661,000 tons of steel, whereas in August it was down to 52,000 tons. Germany in April produced 855,000 tons of steel, and in August 1,123,000 tons. Unless we can manage in some way or other to prevent these terrible outbreaks in our country, we will find our production of steel and iron steadily going down, and the production of Germany and other countries steadily going up.

As the situation, as well as the outlook, were well described by Mr. Peech (chairman) at the recently held annual meeting of the United Steel Companies, Ltd., I cannot do better than quote extensively from his speech.

Mr. Peech said: "I should like to give you an appreciation of the position as I see it now. Ever since the collapse of the boom period in 1920, the coal, iron, and heavy steel trades have experienced the deepest depression, relieved temporarily by the improvement which occurred after the occupation of the Ruhr by the French in 1924. It is, I think, necessary to take your minds back to the commencement of those times in order to obtain a clear view of the situation today, as, however important such temporary improvements, or more acute depressions, may be in the day-to-day business of firms engaged in heavy industries, it is possible to observe the real trend of trade and of the conditions under which our trade is carried on only by reference to a fairly long period."

The governing factor in the iron and steel trades in these past few years has definitely been the large increase in the manufacturing capacity which occurred during the war years, not only in this country, but throughout Europe generally, and which was occasioned by need for rapid and intense production of steel for armament purposes. The increase in productive capacity was proportionately greatest in this country, although in Germany, France, and Belgium, very considerable additions were also made to the pre-war steel making plant.

Change from War Materials.

In the case of all these countries, it has been necessary to turn from the manufacture of war materials to output for purely commercial purposes, and the difficulty in making this change in the direction of the output of these plants has been magnified enormously by the current reduction in the purchasing power of those countries upon which we depended largely in pre-war days for the consumption of our exported output.

At first glance it might be thought that this reduction in purchasing power must have been confined to those countries which were actively engaged in the European war, the financial structure upon which the trade of the world is maintained is so complex that the reduction in wealth of the belligerent nations has undoubtedly affected even those neutral nations from whom large quantities of supplies were purchased during the war.

In our colonies and dependencies there has been a very marked tendency to foster the development of the steel and iron trades, and much has been done by way of bounties and tariffs to protect these home industires and to reduce the importation of steel both from this country and from other European competitors.

While these factors have been operating against us in export trade, the home trade has been literally devastated by the dumping of enormous quantities of steel from the Continent. This has been rendered easy by the increasing depreciation of European currencies in terms of sterling. Until 1924 our steel trade suffered in this respect from the depreciation of the German mark, while the competition of France and Belgium was not so acute. The stabilization, in 1924, of German currency may almost be said, however to have synchronized with the beginning of serious depreciation in French and Belgian currencies, which has continued without material interruption. During the past two years our main competitors in our home markets have been France and Belgium, and the conditions produced by this competition, have resulted in price movements in this country which have been almost fantastic.

Price Movements.

For many years, prior to the war, it was possible to forecast price movements within comparatively narrow limits in the iron and steel trades over a period running, certainly, into months, and one might almost say into years, and the changes which occurred were restricted to those which followed from temporary alterations in the normal course of supply and demand.

So far are we removed from these conditions that the normal working of the laws of supply and demand may be said to have been almost suspended during the past five years—that is to say, the fluctuations in prices caused by circumstances extraneous to these economic laws have completely swamped the effect of any temporary reduction in demand or increase in supply.

This is a picture of the broadest aspect of the steel trade as it has been during recent years, but, had the normal rate of increase of consumption which obtained in pre-war years, continued up to the present, the capacity of all available plants would have been inadequate to meet the world's needs. It is not unjustifiable optimism to believe that the loss which makers have experienced in their output during recent years, can be, and will be, made up before many years have passed by an increase in the rate of demand which is bound to arise if the needs of the world are to be met.

International Steel Cartel.

The fact that Belgium has succeeded in stabilizing her currency and that now only France remains outside the pale—and there is hope that her financial troubles may soon be adjusted—coupled with the formation of the Cartel, emphasizes some of Mr. Peech's remarks and also opens up another phase of the situation which will be dealt with when the Steel Trust comes under consideration.

Before discussing this world-important matter, however, it may be as well to refer to a few remarks made by Roland D. Kitson, chairman of Bolckow, Vaughan & Company, at their annual meeting, when he said that the creation of the Continental Steel Cartel had introduced an important factor into the British Iron and steel Trade. It is common knowledge the British makers have been invited to join and that the matter is now being actively discussed in iron and steel circles. The result of the present deliberation should be clearly understood. The International Steel Cartel, which is made up of French, Belgian, German, and Luxemburg manufacturers, is the direct outcome of the political recarving of Europe. The producers have been divorced from their former markets which are now protected by a ring of tariff walls. The steel cartel is an effort to secure by international agreement the relinking of producers with their markets and the elimination of wasteful competition.

This aspect of the matter was dealt with at some length by Sir William J. Larke, the director of the National Federation of Iron and Steel Manufacturers, in a lecture recently delivered in the Midlands on international co-operation in iron and steel. He pointed out that the large producing centers in Lorraine, which in 1913 produced 3,870,000 tons of pig iron and 2,286,000 tons of steel, the Saar which produced in the same year 1,300,000 and 1,800,000 tons respectively, and Luxemburg, whose output was 2,548,000 tons of pig iron and 1,336,000 tons of steel, were before the war within the German Customs Union, their principal market being the finishing industries of Germany. These areas have all been separated from that country. For example, Luxemburg, which now forms part of the Belgian Customs Union, must now export practically the whole of its products. Lorraine is driven to compete with the pre-war French producers in the French home market, and also to compete with them in the export trade. The United States is the greatest iron and steel producer, with 50 per cent of the world's productive capacity. One of the first problems therefore, which the British iron and steel masters will have to consider in any question of joining an international cartel is whether to look to the east or to the west. An arrangement with the United States obviously has attractions, as she has lost position and importance as an exporter. Clearly the terms would have to be definitely attractive before British producers would consider joining the Continental group.

And now for the Cartel itself, which undoubtedly is one of the outstanding features of the year. The Manchester Guardian Commercial referring to it, says in part:

Description of Cartel.

"The agreements which have led up to the formation of the European cartel are of two kinds. The first is the special 'Franco-German Agreement' and the second is the 'European Agreement,' which gives its name to the Cartel. The former is concerned with questions of the internal economy of the two countries named, and, except in so far as it increases the working efficiency of the Lorraine, Luxemburg, and German iron and steel industries, is not prejudicial to the British steel industry. This agreement settles the contingent of iron and steel products to be imported from Luxemburg and Lorraine into Germany, the politico-economic position of the Saar works, and the question of long-period deliveries of raw-materials, such as the interchange of Lorraine ore and Ruhr coke."

"The European agreement is intended to maintain prices and to stabilize production. A total production figure has been fixed for the participating countries, Germany, France, Belgium, and Luxemburg, and the share of each group in the total production has been allocated. The agreement is restricted to the basic produce, crude steel, and will probably not be extended to the more finished iron and steel products for some time to come. The Western European industries which form the Steel Cartel have special agreements with the works of Poland, Upper Silesia, Austria and Hungary, and Czechoslovakia, and it is expected that these eastern European industries will either enter the Cartel, or themselves form a separate Eastern European Cartel, which will work in close co-operation with its Western forerunners.

"In so far as the purpose of the European Iron Cartel is, as it is stated to be by its members, the maintenance of reasonable prices the syndicate can only be of benefit to the British industry, which has suffered greatly from the dumping of iron and steel products in its markets abroad, by the Western European countries. The danger to British industry comes from another possible development—namely, that the new cartel may pursue a price-cutting policy in oversea markets to the detriment of those producers remaining outside its organization. Now, while it is possible for the cartel to maintain domestic prices in each of the partcipating countries and pursue a price-cutting policy abroad, as has been done by the German industry under the shelter of its protecting tariffs, this result does not appear probable.

"First, the raison d'etre of the cartel has been the avoidance of the heavy losses which Germany has recently sustained on her export trade, while the French and Belgian manufacturers are beginning to realize that their high production for export only means that they are sending goods out of their country at artificially low prices. In the second place, while Britain has since the war lost ground in important markets abroad, such losses have been occasioned as much by the fall in the demand for iron and steel products and the new home industries that have sprung up in overseas markets, as by European competition.

Cartel to Stabilize Prices.

"If evidence were required that the European Steel Cartel does not intend to inaugurate a policy of price-cutting in overseas markets, it would be found in the recently published agreement between the representatives of the German iron and steel producing industry, which has been the prime mover in the international negotiations, and "AVI," the organization of the German finishing industries. While the dumping of cheap steel goods abroad might benefit the German heavy industry, the German finishing industries rightly complained that they were paying high prices in the protected home market, which were used to subsidize their competitors in foreign countries. In consequence, before the German Raw Steel Syndicate, representing the heavy industry, was allowed to enter the international negotiations with the support of its Government and the German finishing industries, the latter obtained the Syndicate's assent to the following conditions, which effectively dispose of the possibility of dumping.

"(a) The aim of the International Steel Syndicate should be the adjustment of supply to demand and the regulation of world market prices, so as to eliminate mutual underbidding in foreign steel markets, which has formerly given finishing industries abroad a great advantage over the home iron and steel consumers.

(b) The international association should not result in an increase of prices to the German steel consumer, but the producing industry undertakes to eliminate the gap between home and domestic prices as conditions in foreign markets improve.

"Adhesion of the Czech, Austrian, Hungarian, and South Slovak steel industries to the cartel has not yet been effected, and troubles have arisen with the Czechs and Hungarians over the fixing of quotas. Conversations with representatives of those countries are going on in Vienna. Polish interests may take a part in them.

"The negotiations between Germany, France and Luxemburg have happily been terminated at Dusseldorf, and the amount of pig iron to be imported by the two latter countries into the former has thus at last been fixed. France is to cover 55 per cent of the German requirements in hematite, and Germany 45 per cent, but other details are yet lacking.

Continental Cartel.

"The formation of a Continental Cartel of steel-tube manufacturers is announced, on the same lines as the steel cartel. The desire is expressed that England will join it on the basis of the average actual capacity of production. Each producing country has established a national syndicate with the exception of France and Belgium, which have united in one group in view of their close relationship. The possibility of an entente with the United States is not considered great, and is declared to be not indispensable, the cartel being persuaded of its ability to meet American competition in overseas markets.

"But let us suppose that the syndicate or combine, or pact, lives and works, what then? We are told that it will mean new and powerful competition, and that if we don't join in the scheme we shall suffer. Let us see! The pact aims at the regulation of output, and lifting of prices to a profitable level. By a profitable level it means such prices for the products of all the associated works, or countries, as will enable those with the highest productive costs to make a profit. It means that if and when the French currency assumes normality, and French exports are no longer artificially stimulated by an unequal exchange, the Germans must not dump steel in any market at a figure which will undercut the French steel. It means many other things; but the big point is that the scheme means higher selling prices and carefully regulated competition, so far, that is, as the products of the four participating countries are concerned. If carried to its logical conclusion it will mean no more German bounty-fed and subsidized dumping.

Hopeful Outlook.

From all the foregoing it will be seen that although the position at the moment is one of extreme difficulty, the future is full of hope with all industries requiring iron and steel.

As is very evident, with the heart taken out of everyone for so long and with expenses naturally cut to the bone, new processes have been few and far between. One, however, that deserves special mention is a new system of upgrading gray cast iron. This new process has been elaborated by a German metallurgical works with a view to the considerable improvement of the strength of ordinary cast iron. The conditions have only just been made known. They do not so much imply the freedom of the cast iron from sulphur and phosphorus, as in forging steels, as the finest possible division of the graphite, which is distributed throughout the mass of the iron in thin flakes, interrupting the continuity of structure of the metal and thereby reducing its strength. It is theoretically known that the strength in the case of the finest division of the graphite may be at least double that in the case of the graphite present in comparatively large flakes. Up to now attempts have been made by chemical means and by the addition of suitable alloys and a special heat treatment after casting to reduce the quantity of graphite and favorably influence its distribution. By another method steel scrap is added to the cast iron, and the charge is superheated in a cupola or electric furnace. This method, however, necessitates the use of costly plant.

In the new process, on the contrary, no special blending is required, ordinary cheap pig iron being the initial material. The charge is subjected to mechanical mixing on the open hearth by a shaking device, and as a result the iron is thoroughly freed from gases, its structure rendered homogeneous, and the finest division of the graphite attained. This result is attained with perfect certainty. The limits of analysis of the material for the process are very wide, so that very careful blending is unnecessary. Bending strengths of 50 to 60 kilograms per sq. mm., a tensile strength of 30 to 40 kilograms per sq. mm., and a degree of Brinell hardness of 190 to 230 are obtained. The cost of the mechanical mixing procedure corresponds to an expenditure of current of 0.5 kw. per ton; the installation is cheap and not easily deranged, and special attendance is not required. The moulds do not need to be dried, and no subsequent treatment of the castings is necessary. By the use of the new material, it is claimed, castings can be made 50 per cent lighter and correspondingly cheaper. Hollow pieces, which are very expensive when made of forged steel, may be made with the same strength in castings. The material has particular advantages for portable machines, in shipbuiding, the construction of motor vehicles, and for agricultural machinery.

Epoch-making Discovery.

The Acht Uhr Abenblatt gives details of yet another "epoch making discovery," which is going to place Germany "above competition in some of the most important articles of export." This time it is a process of transforming iron into steel by chemical action, patents for which have been acquired by the Dye Trust, and the application of which is so far advanced that "in a very short time" the old methods will be "entirely superseded." Experiments with the new process were carried out in the Baden Aniline Works, which, of course, belong to the trust, and they ultimately produced a metal "in every respect unquestionably superior to the very best furnace steel, "being at the same time harder and more elastic. To this must be added that the cost of production of the new steel is "not inconsiderably lower" than that of the old.

Once more Sir Robert Hadfield has shown his public spiritedness for he in conjunction with Viscount Bearstead, has provided the equipment of the metallurgical section of the new Research Laboratories of the Applied Science Department of Sheffield University. The opening of the laboratory was one of the outstanding features of the year, and Sir Robert showed by some remarkable figures how intimate the connection between sound technical training and industrial prosperity. He estimated that in the various companies operating in the Sheffield district from $4,000,000 to $5,000,000 in capital was invested equal to about $2,750 per person employed. From 50 to 55 per cent of the amount is engaged in iron and steel undertakings, about 30 per cent in collieries, and from 15 to 20 per cent in the engineering cutlery, electroplating and other trades. Practically all these industries have developed in the past and depend in the future on the progress of scientific investigation, and those who are most backward and in the worst plight now are those which have neglected the benefits of research. The way in which steel has held its own proves this as well as any single instance, though Sir Robert's outstanding achievements in this particular field prevented him from using it as an illustration. The Sheffield University, which has just come of age, has been a powerful factor in maintaining the technical efficiency of the district, and has met with adequate, if not over-liberal support from manufacturers who appreicate the value of having such an institution in their midst. Sir Robert calculates that the cost of the University represents only ½ per cent on the capital invested. Sheffield certainly gets its scientific equipment cheaply.

Third German Steel Trust.

News of considerable importance regarding the formation of a third German steel trust is just to hand. The Linke-Hoffmann-Lauchhammer A. G. of Breslau has been constrained to undertake measures of reorganization which will at the same time involve the dissolution of the last German vertical trust of importance and the formation of a third German steel trust, embracing the bulk of the Central German steel works.

The Linke-Hoffmann Company originally produced locomotives and railway rolling stock. During the immediate post-war and inflation period, when the vertical trust principle gained popularity, the firm acquired control of a number of German mines and steelworks, now known as the Lauchhammer group, with the idea of assuring its supplies of raw material, particularly in view of the loss of a portion of its sources of supply in Upper Silesia. The undertaking, like all the concerns, from Stinnes downwards, built on the vertical principle, has been unable to hold its own against the economic developments which have followed the stabilization.

The Lauchhammer group of steel works, comprising the Lauchhammer, Riesa, Groditz, Wittenau, Burghammer, Elbingerode, and Brotterode works, together with the Henningsdorf and other works in which the Linke-Hoffmann firm has a controlling interest, are to become part of a new steel trust to be known as the Mitteldeutsche Stahlwerke Gesellschaft (Central German Steelworks Company), which is to be founded with a capital of 50,000,000 marks ($12,500,000).

It will apparently not be long before the remaining locomotive and rolling stock business of the Linke-Hoffmann firm, released from the vertical organization, is drawn into the horizontal trust movement which is making such rapid strides in German industry. Negotiations for the formation of a rolling-stock trust are already in an advanced stage, and a locomotive trust is being discussed.

By the time this article appears in print, it is honestly beleved by all sections of the iron and steel trade that the coal strike will be absolutely and literally a thing of the past, and that the country will have entered upon a period of prosperity unexampled for many years, and further there is every appearance of long life and stability for all sections of the trade, while there is ample for all comers with prices on a firm and profitable basis.

Improvements in Rolling Mill Equipment

Factors Controlling Rolling Mill Construction Outlined—Changes to Various Types of Mills Indicate Material Advances—Pilger Mill Attracting Much Attention

By **FRANK C. ROBERTS, JR.***

THE World War demanded an increase of steel in the heavier forms. The United States responded in 1917 with a production of 44,619,200 tons of ingots. It took eight years, (1925) for this country to demand a production of 44,140,800 tons; the year just closed will show about the same production.

For some few years the capacity for production of steel, melted and bloomed, has not been given much, if any, impetus, the demand having controlled this situation. The intensive thought of the steel industry has been centralized upon the rerolling and finishing of the product. Firstly, for greater unit production, and secondly, for greater diversity of products. These movements may be called the "signs of the times." In the first development, we find more strength and power, greater speeds, and fewer men. In the second—greater adaptability, greater ingenuity of design, more space for rolling, more space for storage—the rolling mill of today, for shapes and bars, is also functioning to some extent, as a warehouse.

Next to the recent rapid development in alloy steel demanded by the improved automobile, the three most important factors influencing the steel industry in all probability are:

(a) The so-called hand to mouth buying.
(b) The greatly improved railroad movement.
(c) The abolition of the "Pittsburgh Plus" basis of selling.

The above, coupled with restricted immigration, are forces which have been and are at work determining the manner of growth of our whole economic structure and as usual, the steel industry is constructively taking advantage of its opportunities.

Happenings in Past Years.

The thought in presenting this article is to sketch in a general way what has taken place in the rolling mill industry during the past few years. This development is, after all, only a part of, and in conformity with the forces outlined above.

The rolling mill equipment business is naturally based upon the requirements of the market for iron and steel. Some 50 years ago, the "steel era" started, and in the course of events, ingot production increased. The demands at first were naturally put upon the blooming mill and its accessories, such as the manipulator, reversing engines and finally, the reversing motors. These mills have gradually been increased in size up to 40 inches, 45 inches and today the largest installations are 54-inch pitch diameter of pinions. The manipulator has been steadily improved and with the reversing motor, has received the most intensive study from an engineering standpoint. The hydraulic manipulator in the past has proved itself most dependable. On the other hand, the new electrically operated manipulator seems to be gaining in favor due to the simplicity in its power factor and to increased possibilities in speed, and accuracy of manipulation.

The sheared plate mill industry had been overequipped even before the World War, and yet much additional tonnage was added at that time. As a result, few improvements have been made during recent years in the heavy plate mills. However, the desire to save labor in shearing plates, has put greater demands on the universal plate mill, and as a result, the designs have progressed accordingly. The data available shows that the widest universal plates rolled now are 48 inches wide, and the narrowest 6 inches wide, and the maximum tonnage is 27,000 tons per month.

Largest Universal Plate Mill.

It is also interesting to note that the largest universal plate mill was built in England for Stewarts & Lloyds, Ltd. The vertical rolls are 26⅝ inch diameter and the horizontal rolls 34 inch diameter by 96 inch face. The maximum width rolled on this mill to date is 48 inches down to ¼ inch gauge and the minimum gauge and maximum width is slightly under 3/16 inch by 36 inches wide. The vertical rolls are designed for adjustment to roll minimum universal plates 8 inches wide.

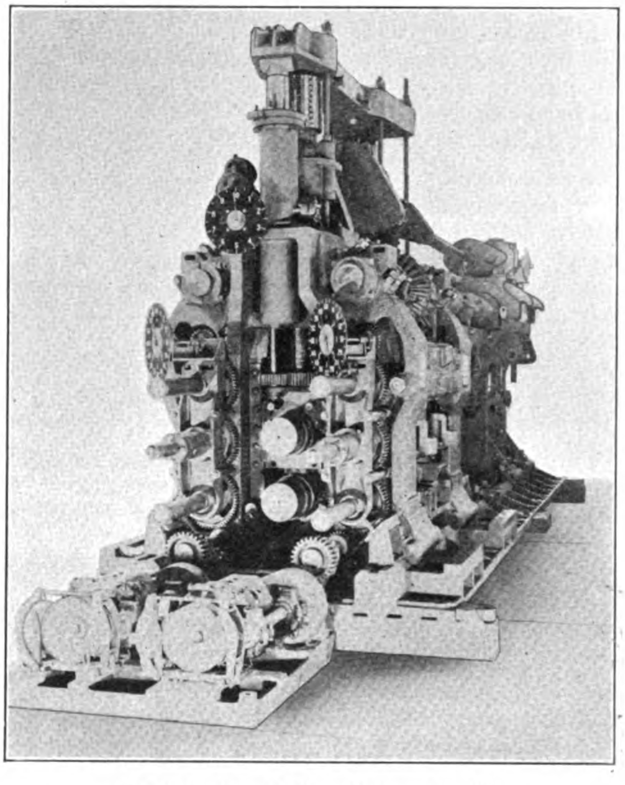

FIG. 1—32 x 83-in. Universal mill.

The four-high plate mill is now being used in conjunction with the ordinary sheared plate mill and the universal plate mill as a finishing mill, due to the fact

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*Mackintosh-Hemphill Company, Pittsburgh, Pa.

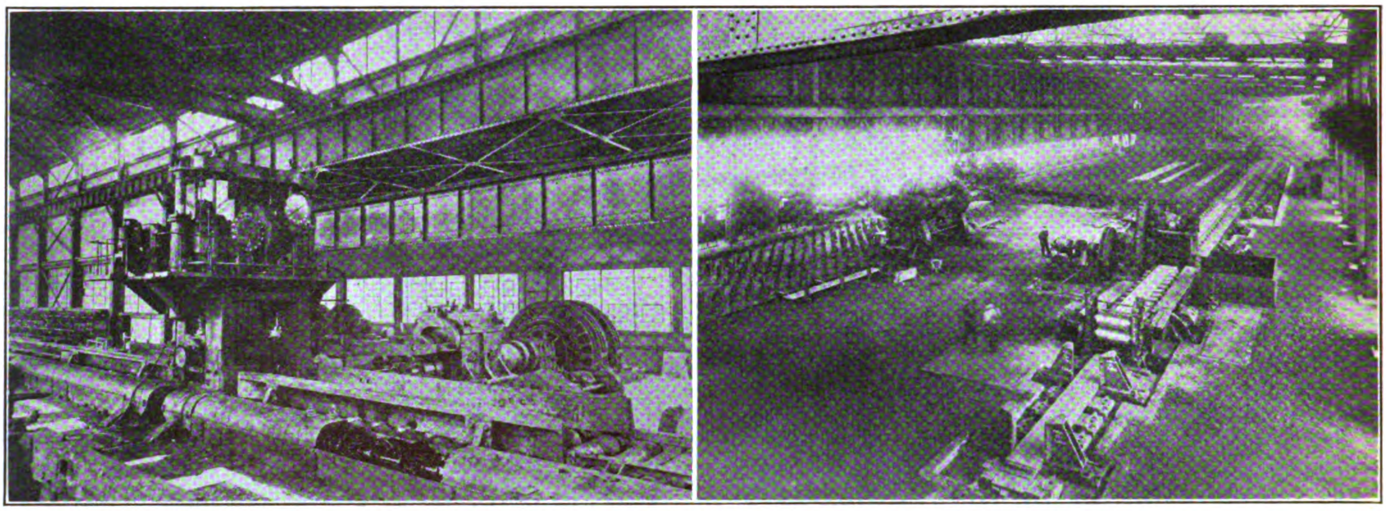

FIG. 2 (Left)—35-in. blooming mill. FIG. 3 (Right)—Shear and piler at finishing end, 30-in. universal mill.

that it produces a more accurate gauge and finish on wide thin plates.

Four-high Continuous Mill.

Another new development along these lines is the use of a four-high continuous mill for accurate rolling of thin plates and wide sheets. The four high principle has long been in operation, but not until this year has the principle of roller bearing backing-up rolls been adapted. The method acts as a great power saving factor.

In this connection, the most advanced development this year seems to be in rolling wide strips continuously in two-high and four-high mills. This method appears most reasonable from an engineering standpoint, but its practicability in detail remains to be proven by the operating departments of the industry. There are many questions to be solved, but it is universally admitted that the four-high mill is the most forward step in improving the sheet and strip mill branch of the industry.

The operators in the past had always thought it necessary to roll thin gauge sheets in packs. This method was developed even before the rolling mill was introduced, the sheets at that time being hammered out in packs. Thirty years or so ago, the process of rolling sheets in packs on a continuous mill was seriously considered. This, however, was never definitely undertaken until 1902-3 when a semi-continuous sheet mill was tried out. The results, as reported, were not satisfactory, mainly due to loss of heat at slow rolling speeds and other causes beyond control at that time. Since then, however, these difficulties have been overcome, and the continuous rolling of wide sheets or strips with a four-high mill as a finisher is the triumph of today.

The automobile industry has, without doubt, been the big factor during the past few years in demanding greater production, more accurate gauges, and better finish. The above mentioned improvements are, therefore, timely and in relation to the demands of more exacting consumers.

Use of Roller Bearings.

One most noteworthy advance is the use of roller bearings in the mills and so far, seems to have had more effect in the strip and sheet mill industry than any other line. The applications so far, have been based on the results of tests over a period of three

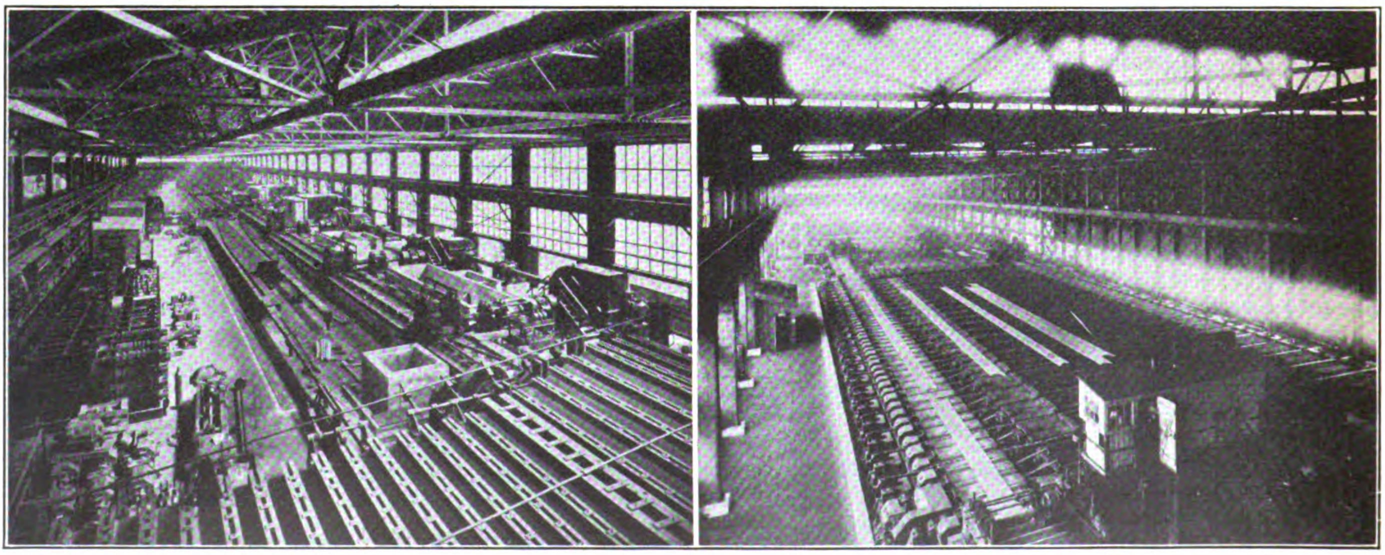

FIG. 4 (Left)—Cross country mills, illustrating large bevel gear drives (at right).
FIG. 5 (Right)—Aiken type plate mill hot bed.

years, and have demonstrated that the roller bearing can be successfully applied to withstand the enormous load developed on main roll necks. These bearing designs are able to take both radial and thrust loads and have an added advantage of positive roll alignment and large load carrying capacity to withstand heavy shocks. It is a well known fact that a large percentage of power used for driving the main rolls in rolling mills, is wasted on roll neck friction. Therefore, by the use of roller bearings on roll necks, tests conducted, have shown a total power saving anywhere from 25 per cent to 60 per cent for roller bearings over standard plain bearings. There is also an additional saving in lubrication and maintenance. Roller bearings have been applied so far to rod mills, billet and bar mills, strip mills, structural shape mills; also pinion stands and gear reduction units. The mills equipped so far, range in size from 10-inch rod mills to 52-inch universal wide flange beam mills, requiring roller bearings with load capacities up to 1,500,000 lbs. each. The main point in connection with proposed installations, and this, combined with the capacity required, determines the possibility of installing roller bearings on rolling mills. There is no doubt today, the roller bearing will be the bearing of the future for mills where the limitations are such as to allow such installations with sufficient capacity to carry the necessary loads.

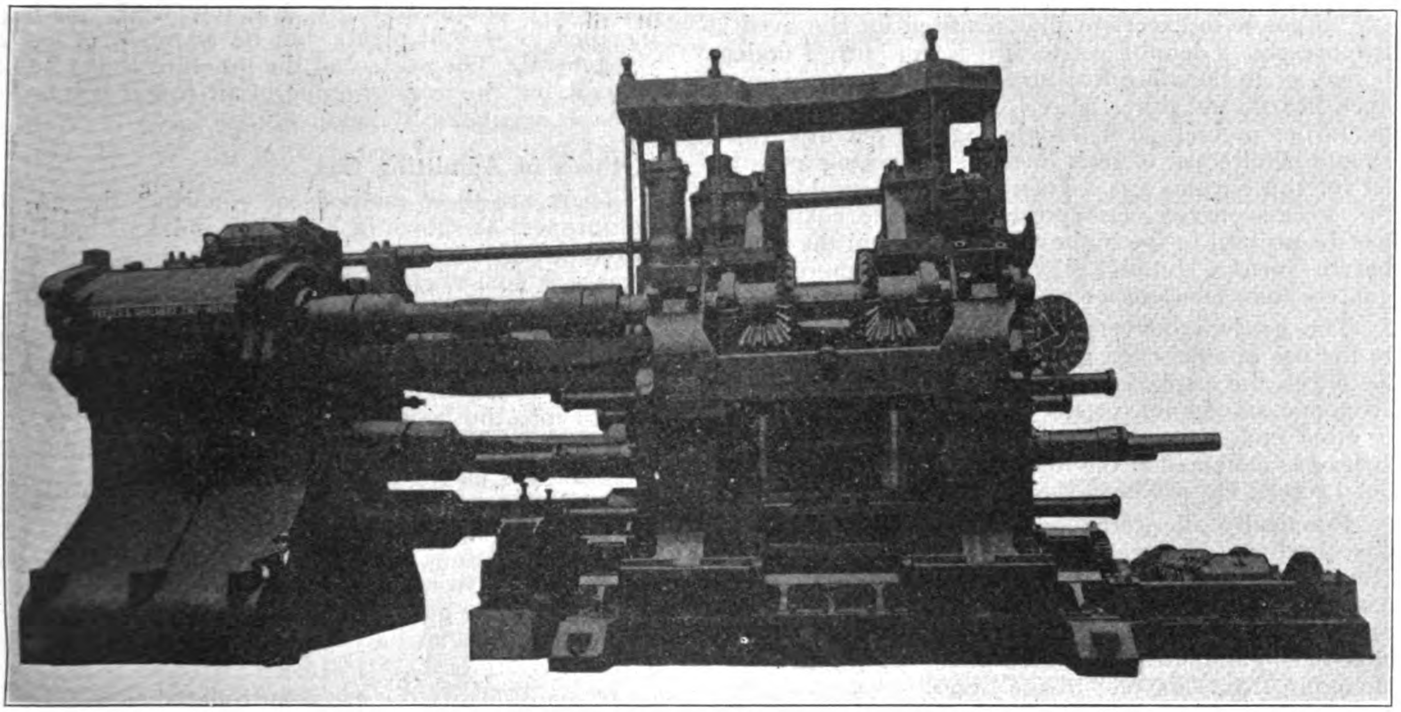

FIG. 6—Largest universal mill in the world installed at Stewarts & Lloyds, England. Designed by Mackintosh & Hemphill Company, and constructed in England by Fraser & Chalmers.

The recent building demands have naturally created further uses for structural shapes. The building industry has also recently increased their demands for wide flange beams. There is some doubt in the minds of building engineers as to whether the welding process of erection will prove to be as successful as the riveting process has proved to be. Should it supersede the older method, the demand for the present sizes of structural shapes will change, the tonnage, however, will not be affected.

Three-high Structural Mill.

For the average jobbing structural mill the three-high mill with traveling tilting tables, seems to be the most satisfactory. For production work on smaller shapes, the cross country mill has been shown to be the most economical. As stated above, the universal wide flange beam mill is gaining in favor and, apparently, will prove the most satisfactory mill for production of heavy beams. The development of this type of mill, however, more than the other structural mills, will be influenced almost entirely by the demands of the building trade.

The modern tendency in rolling pipe and tubes seems to favor the seamless method. There are the two distinct types— the piercing and the push-bench.

The push-bench process requires a greater amount of labor and for this reason, has found the most favor in Europe, where the cost of labor is low. The roughing method in this process is somewhat similar to that of manufacturing shells developed during the war and also the present method of manufacturing high pressure gas containers.

The piercing process originally of German origin, is now divided into two classes, the automatic and the pilger. Both of these start with the Mannesmann type piercing machine. Installations made so far in this country with pilger mills are designed to produce tubes at least 15 inches in diameter with a possibility of reaching 20 inches diameter. The automatic mill at present, has not produced such large diameter of tubes, but seems to be the better mill for production work. A larger automatic mill will be installed shortly and the industry as a whole, is keenly awaiting the results. There is every reason to believe that its performance will show the most satisfactory results as to sizes as well as to production.

Coke Oven Gas for Open-Hearth Furnaces

Developments in the Application of Coke Oven Gas Are Discussed—Present Practice in Use of Both Gas and Tar Fully Covered—Economies Are Substantial

By CHARLES LONGENECKER

BY-PRODUCT Coke Oven gas is rapidly becoming the predominant fuel in large steel plants. The reason for this is purely economic. Coke is essential as a fuel for blast furnaces and can be produced at the lowest cost in by-product ovens. When coal is coked in these ovens approximately 10,500 cu. ft. of gas are evolved per ton of coal, of which quantity 6,200 cu. ft. are required for heating the ovens while the remaining 4,300 cu. ft. are surplus. As this quantity of gas is in excess of that required for the ovens, it represents a definite waste, if it is not burned under boilers or in metallurgical furnaces. In a steel plant, open hearth and other large furnaces, consume great quantities of fuel, so it is only logical that attention should be directed to such furnaces in seeking an outlet for this surplus gas. Then too it is desirable that this excess energy, as represented in the coke-oven gas, be utilized to the highest efficiency, and the open-hearth furnace fulfills this requirement more adequately than many other types of furnaces.

The gradual conversion of open-hearth furnaces to the use of coke-oven gas, as a fuel, means, in most instances, the displacement of producer gas. From an economic standpoint, producer gas is to be preferred to other fuels, other than coke-oven gas, but with this latter gas delivered at the furnace at a cost of 10 cents, per 1,000 cu. ft., producer gas can not compete.

Practically all of the large steel plants installed gas producers before coke-oven gas was adopted. Hence, it is possible to supply either fuel to the furnaces as occasion demands. As the producer gas is delivered to the furnace through the regenerators, and coke-oven gas at the ports, there is no confusion when changing from one fuel to the other.

Coke-Oven Gas Burned Over Sunday.

The opportunity to utilize either of the two fuels proves very advantageous in holding the furnace at heat over Sunday. On this day there is usually a greater surplus of coke-oven gas than during the other six days of the week, so that this gas can be supplied to those furnaces which on all days, except Sunday, burn producer gas. Such a change will allow the gas producer to be taken "off the line," over Sunday, and the cheaper coke-oven gas supplied in its stead. This plan has been adopted at several plants, with very gratifying results as regards economy.

From the holders, located near the ovens, the gas is distributed to the points of consumption at a pressure dependent upon the distance the gas is to be transported, and the size of the pipe line. As a pressure, approximating one pound, is desired at the furnaces, the size of "booster" must be such that this pressure will be maintained.

The common practice in conveying the gas to the furnace is to drop a branch, from the main gas line, near each end of the furnace. A pressure regulating valve is placed in this branch, and the gas passed through this to the burner, or burners. Very frequently a second line from the branch to the burners is installed in order that the regulating valve may be by-passed. The flow of gas to the individual burners is controlled by means of a gate valve.

Economy of operation is influenced by the control of both air and gas at the furnace. In other words the quantities admitted to the furnace must be sufficient, and in the correct proportion, for efficient combustion. Equipment for the automatic control of air and gas is unquestionably desirable, and has been installed in several plants, but its adoption is not as yet general. The control of the pressure of the gas is general, but the proportioning of air to gas is in most furnaces regulated by hand.

Methods of Admitting Gas.

There are three methods of admitting the gas to the furnaces as shown in Figs. 1, 2 and 3. That illustrated in Fig. 1 has proved very satisfactory where the furnace is constructed with a single gas port such as used for burning producer gas. A 4-inch pipe, through which the gas flows, is laid within one of 6 inch diameter. It terminates at the inner surface of the port side wall, at which point the gas is mixed with the air and carried into the furnace.

Figure 2 shows the method most generally adopted. Here the gas passes into the furnace through a water cooled burner placed at an angle so that the flame will spread over the surface of the bath. The pressure must be strong enough to give direction to the gas and prevent it from rising. Of course the air current flowing over the gas will assist in controlling the path of the flame. A tar burner is usually placed over the gas burner.

In many plants the gas is introduced in a manner conforming to the practice found most satisfactory for buring natural gas. Two 4-inch pipes enter the furnace from the sides and deliver the gas in front of a wall about 12 inches high. The air passing over this wall mixes intimately with the gas, and combustion is immediately effected. Pressure of gas in the feed pipes must be high enough to insure forcing the gas to the center of the furnace in order to prevent the burning out of the side walls.

The practice of water cooling parts of a furnace is now so general, whatever fuel is burned, that it is necessary merely to direct attention to this feature.

Light Gas Not Troublesome.

When coke-oven gas was first burned in open-hearth furnaces, it was anticipated that the light gas would have a tendency to rise and cause excessive cutting of the roof and side walls. In some cases this was true, but today refractory repair costs, per ton of steel, are less for coke oven gas than for producer gas in the ratio of about 1 to 3. Where success was not attained the difficulty was frequently traced to the faulty manner of introducing the gas. In one plant, burning producer gas, the coke oven gas was mixed with the producer gas as it flowed through the flue to the reversing valves. Satisfactory results were not obtained.

In furnaces where the coke-oven gas is burned efficiently 300 to 350 heats can be tapped before repairs need to be made, while on the same furnace burning producer gas partial reconstruction is necessary after tapping about 250 heats.

Comparative results on producer and coke-oven gas, when burned in the same furnace, show a coal consumption, for the production of the former, of 580 lbs. per ton of steel, while the consumption of the by-product gas averaged 11,000 cu. ft. The time of heats favored producer gas, but the quality of the steel was somewhat better when coke gas was burned. This was largely due to the fact that the gas was desulphurized before it passed into the line to the furnaces. It contained no more than 3/10 lbs. of sulphur per 1000 cu. ft. of gas. To obtain a high quality of steel, it is necessary that the sulphur content in the gas be reduced to, or below, this figure. To secure this reduction of the sulphur content, the gas must be desulphurized in some manner unless the quantity of sulphur in the coal, fed to the ovens, is very low. It is also desirable that the moisture content of the gas, as it enters the pipe line, be held to a minimum in order that there will be no appreciable collection of condensed water in the lines.

Tar Burned with Gas.

As tar, like gas, is a by-product in the manufacture of coke, and as it is also an excellent fuel, it can be burned either alone or with the gas. In many plants tar and gas are burned simultaneously. The tar gives luminosity to the flame, which is a highly desirable feature. It is accepted practice to heat the tar to about 180 deg. F. at which temperature it flows freely. Steam at a pressure of 100 lbs. atomizes the tar, the pressure of which is approximately 90 lbs.

In most plants, furnaces, other than open hearth, must be supplied with gas, or tar, and, as the supply of each varies, some arrangement is advisable to permit a change at the furnaces from one fuel to the other, either completely or partially. Where the change is complete, a shifting of valves alone is necessary, but where it is desired merely to increase or de-

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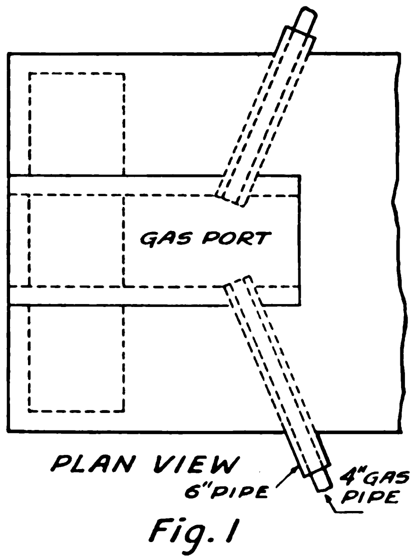

Fig. 1

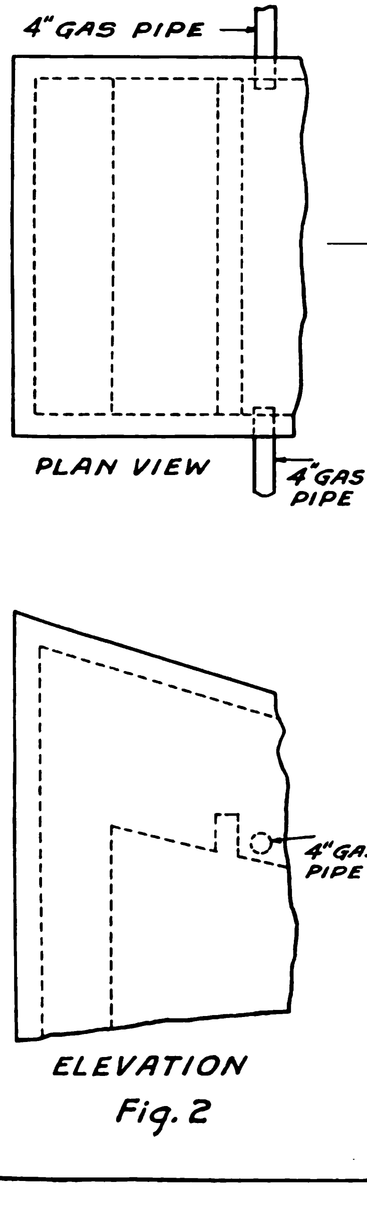

Fig. 2

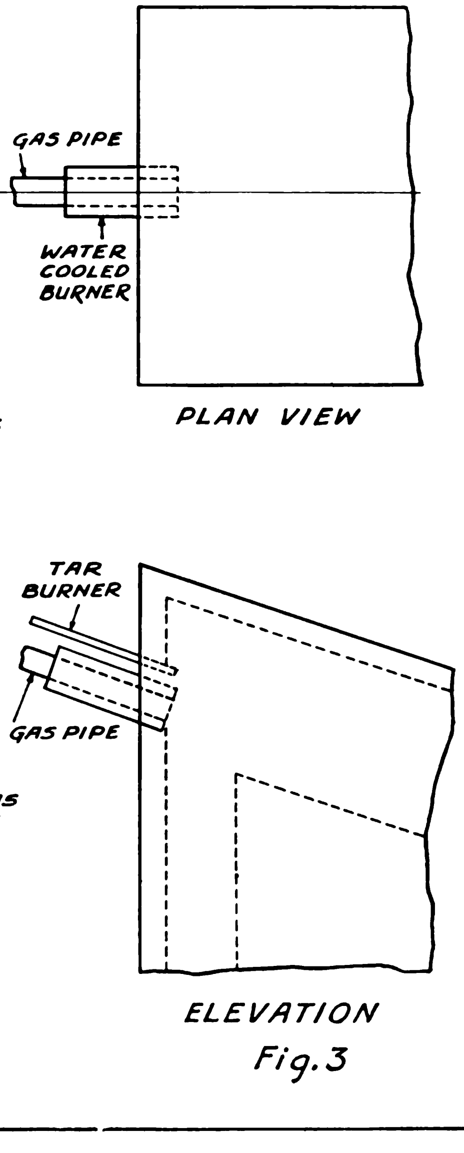

Fig. 3

FIG. 1—In this construction gas is admitted to a central port from both sides of the furnace.

FIG. 2—Several plants follow this practice, as used for burning oil, etc.

FIG. 3—The method here adopted is similar to that used in burning natural gas.

ELECTRIC FURNACES FOR MELTING METAL

The Subject Is Presented in a Comprehensive Manner and Treats of Practice in Melting Both Iron and Steel—Methods of Control and Various Furnace Types Described

THE trend of electric-furnace development can now be said to be on a normal and sound economic basis. During the World War the use of electric furnaces received a tremendous impetus which resulted in a rapid and in some cases an unhealthy growth. The electric furnace was heralded as a metallurgical cure-all in which the "magic" of electricity made a product inherently superior. No one was super-critical at the time, but later the inevitable reaction set in and the electric furnace was blacklisted in many places. The disillusionment was painful in some cases, but on the whole it can not but have a beneficial effect. Both the proponents and opponents are now more frank in recognizing the limitations as well as the peculiar assets of the electric furnace, and it is naturally gravitating to its proper place in the metallurgical industry.

Limitations and Applications of the Electric Furnace.

As an example of recognized limitations in the electric furnace, we no longer find any serious attempts being made in this country to smelt iron ore electrically. Although electric smelting of iron ore has been proven technically feasible, it has been definitely shown that with the present supply of metallurgical coke and its cost as compared with that of electric power it is economically impractical in North America. There is no quality factor in this case to favor the electric furnace because most pig iron is converted to steel, and the electric smelting furnace does not produce good foundry iron. There are, of course, a number of so-called direct processes for the production of steel from iron ore where the use of the electric furnace is advocated, but these are on a different basis. In most of them the ore is reduced at low temperatures with fuel and the resultant sponge iron is melted and refined in an electric furnace. Here the sponge iron is on substantially the same basis as a low grade of scrap. Great interest is being shown in these direct processes and several semi-commercial trials are being made at present. In one of these an attempt will be made to melt the sponge iron in an open-hearth furnace. The open-hearth furnace is as yet an unknown factor in melting sponge iron, but the electric furnace has been so successful on experimental work that it would seem to have every chance of success if sponge iron can be obtained as cheaply as an equivalent grade of scrap.

Alloy and Tool Steels.

In ferrous metallurgy it is conceded that in many instances the electric and fuel-fired furnaces are not in direct competition, but each has a field of its own. The advent of the electric furnace has been almost directly responsible for the rapid advance in high-grade alloy and tool steels and the economic production of these steels is virtually impossible in fuel-fired furnaces. An exception to this is in crucible steel which, although it has been driven from the field by direct competition, has never been surpassed on a quality basis. It has been superseded because of the larger scale and greater convenience and comfort with which the electric furnace can be operated, and because the latter can produce as good steel from a lower grade of raw material.

Steel Castings.

The field of greatest volume development has been in steel castings. The extent of this development can be visualized when it is known that of 380 steel foundries in United States and Canada, 199 or more than 52 per cent, are equipped to produce electric steel castings. The electric furnace has found greatest favor in the smaller foundries where it has replaced converters and in some cases small open-hearth furnaces, but no appreciable inroad has yet been made on large open-hearth furnace installations. Indications point to the fact that the high-grade alloy steel and steel castings will continue for some time to be the most fertile field for electric steel, although a start has been made in the production of electric steel rolling ingots on the North Pacific coast.

Cast Iron.

The development of electric-furnace gray iron and malleable iron has been slow, but has recently gained a great impetus, and is now receiving more interest than any other phase of electric melting. Cast iron has long been considered as a low-grade product to be made as cheaply as possible and sold at low cost. But there has recently been a sharp revision of this idea. The encroachment of steel and malleable iron castings on the gray-iron field has made the gray-iron founders look to their laurels. With the spur of competition and the ever-increasing strictness of specifications came the rather belated recognition of hitherto unthought of possibilities for high-quality cast iron. The electric furnace has played an important part in this advance in gray iron; and as a consequence there has grown an interest in electric gray iron as great as was ever evinced for electric steel. As with steel, the advantage in the use of the electric furnace are in the production of high-quality iron and ability to use lower grade charges than the cupola. This is not to say that high-grade cast iron can not be produced in the cupola, but the advantages of super-heating, uniform and adjustable composition, and clean, gas-free metal, make it far easier consistently to produce high-quality castings. Moreover, there is a difference between electric-furnace and cupola gray iron that has not been adequately explained. With the composition the same the electric-furnace iron will be much finer grained and, as a result, stronger and tougher. Furthermore, good castings can be produced with the electric furnace from either pig and scrap mixtures or all scrap charges. The scrap can be either iron or steel, in large pieces or as borings and turnings. When a large proportion of steel scrap is used carburization is accomplished by the addition of crushed coke or electrode butts and the product is known as synthetic gray iron. A few years ago it was generally thought that borings could not be easily melted, but charges of part borings and part larger scrap are now standard for some furnaces.

Economics of Electric Melting.

The matter of relative melting costs is in many cases being disregarded, for only under exceptional conditions can iron be melted cheaper in the electric furnace. But as the cost of melting the iron is only a fraction of the total cost of a finished casting, where quality is paramount, a comparatively high melting cost is easily carried. Take for example the extreme case of piston rings where the finished product sells at the rate of several thousand dollars a ton. A slight difference in melting cost is overshadowed by the question of quality. Costs, however, are not greatly increased. One manufacturer reports that when working on a 24-hour basis producing gray iron from cast-iron scarp, steel turnings, and punchings the total average melting cost is $14.48 per ton.

Malleable Iron.

Scarcely less than the interest in gray iron is that in electric-furnace malleable iron. This is being made both from pig-iron scrap mixtures and synthetically from steel scrap. While duplexing is used on both gray iron and malleable, it has found more favor with the latter, and so-called cupola malleable which is melted in a cupola and superheated and adjusted chemically in an electric furnace is making rapid advance.

Permanent Mold Castings.

A recent innovation is the continuous melting and pouring of electric-furnace gray iron to supply metal for permanent mold casting. For economic and metallurgical reasons these molds should not be allowed to cool between casts and a continuous supply of metal is the only feasible means of operating them.

Non-Ferrous Metallurgy.

In the non-ferrous field, conditions are somewhat different. There we find the electric furnace competing directly with fuel-fired furnaces and constantly gaining headway. While, as in ferrous work, quality is the byword in electric melting, other factors such as absence of metal loss and contamination, better control of composition and temperature, convenience and better working conditions play almost as great a role in favoring its introduction. While it is no doubt true that just as good quality metal can be produced in fuel-fired furnaces there is no comparison as to the ease and consistency with which high-grade castings can be made from the electric furnace.

Just as the direct-arc furnace is supreme in the ferrous field the indirect arc and induction furnaces are peculiar to non-ferrous melting. The direct arc is not suitable for volatile metals and the general conditions such as relatively small capacity, and lower temperature, with consequently less refractory trouble, favor the indirect-arc and induction types of furnace.

Electric Heating Furnaces.

Electrically heated soaking pits are being advocated for the reason that less scale will be formed and the ingots can be heated more uniformly and surely to a temperature that will neither be too high or cause tearing in the rolls. Similarly, in all heat-treating processes, the purported advantage of doing it electrically is in more uniform and controllable temperature and atmosphere. In electric carburizing it is claimed that a regular schedule of uniform cycles can be operated with no necessity for taking test pieces.

Units of Higher Power.

The trend in electric-furnace development is definitely toward more highly powered units. This movement is not new, inasmuch as high-powered furnaces, notably the 'Lectromelt have been on the market for a number of years. But recently the power input of some other furnaces, such as the Heroult and Detroit rocking furnace, has been increased from 25 to 50 per cent, with the result that the melting time and the power consumption have both decreased. The late Dr. Carl Hering was credited with saying that the only really efficient furnace is the electric fuse; it is solid one instant and molten the next, because of the relatively tremendous power supplied. Power can be increased readily only by increasing the voltage, which necessitates multiple-voltage control on the furnace, a high voltage for high-power input during the melting down period when there is no danger of over-heating the furnace, and a lower one to be used during the refining or holding period. The Heroult furnace is now using a third and still lower voltage when starting to melt a cold charge. This tends to reduce the large surges which are characteristic of this period.

An innovation in arc-furnace design has been made in the so-called Kay furnace. The lining converges toward the spouts, one of which is at either end, thus making the path of the metal narrower and deeper, which in turn enables the metal to be poured from a considerable depth beneath the slag.

Electrode Control.

In electrode control for electric furnaces the trend is for greater simplicity and reliability. The General Electric Company has developed an automatic electrode control which eliminates the excessive strains to which the Thury regulator was exposed, by moving the electrode from the old to the new position in one step instead of in a series of small steps as in the Thury.

Power Demand Limitator.

Another new apparatus for power control which should prove extremely useful is the Edmore power demand limitator. This instrument serves both consumer and power station by limiting the power which can be drawn by a furnace. It is set at the maximum contracted demand and when the load on the furnace exceeds this figure it operates a relay on the control panel which raises the electrodes and reduces the load. It can be set to operate instantly or after a specified period. With such an apparatus installed an operator can push the furnace to the limit without any danger of running up an excessive power bill.

Multiple Voltage.

The multiple-voltage idea has been carried over to the Ajax-Wyatt type of induction furnace with excellent results at one plant as reported by Du Bose in volume 87 of the Electrical World. Each of five Ajax furnaces has been provided with transformers with 12 secondary taps so that the voltage can be varied from a minimum of 20 volts to a maximum of 320 volts. This enables the operator to keep the power input constantly at the best figure and has resulted in a saving of 30 per cent over the previous cost of melting and 50 per cent on labor. Some progress is evidently being made in constructive refractories for this furnace inasmuch as linings have a life of about 4000 heats.

High-Frequency Furnace.

The furnace that has made the most rapid progress recently and about which great interest centers at present is the high-frequency or ironless induction-type of electric furnace. This principle of heating was developed by Dr. E. F. Northrup and has been in use on laboratory and small-scale metallurgical work for a number of years. In these installations the Tesla oscillatory circuit is used with a mercury-electrode spark-gap to generate a very high-frequency oscillating current. It served excellently to generate the high frequency necessary for small furnaces, but is unsuited for larger scale industrial work because the highest powered unit uses only 35 kw. and, but 50 per cent of this is available at the furnace. For experimental work and certain types of small-scale metallurgy the cost is inconsequential as compared to getting the desired results. But for quantity production efficiency is important. Fortunately, the frequency needed to produce efficient heating varies inversely as the square of the diameter of the object to be heated and for commercial size units fairly moderate frequencies are sufficient. Generators have been built to supply single-phase power at 480, 960, and 1920 cycles, in quantities as high as 600 kw. It is probable that 960 cycles will be most generally used. Naturally, a generator supplying power to such a highly inductive load would operate at an extremely low power factor unless corrected by static condensers, and power condensers have been one of the big problems of this development. However, great progress has been made and it has recently been announced that an oil-cooled condenser has been built which is capable of observing 100 kva. in one unit. This method of heating seems potentially capable of much more than its present development.

As to electrical efficiency the high-frequency induction furnace is about on a par with other types with the exception of the Ajax type of induction furnace. Both the high-frequency and Detroit rocking furnace can melt about 7 lbs. of brass per kwhr., while the iron ore induction furnace will melt in excess of 10 lbs. per kwhr. In a recent test a high-frequency furnace melted 350 lbs. of Armco iron at the rate of 700 kwhrs. per ton, which compares favorably with arc-furnace practice.

High-Temperature Laboratory Furnace.

According to J. Mitchell and W. B. Mitchell in volume 25 (1926) of the Transactions of the Ceramic Society of England, a laboratory furnace for high temperatures has been developed in which molybdenum wire is used as a resistor and is protected from oxidation by cracking ammonia over iron filings at 700-800 deg. C. Great uniformity of heating is claimed for it.

Coke Oven Gas for Open Hearth Furnaces

(Continued from page 33)

crease the respective quantities, on individual furnaces, automatic control serves very satisfactorily. When burned alone the tar consumed, per ton of steel, will vary from 30 to 35 gallons on large furnaces. On small furnaces the consumption may reach 40 gallons.

While the stack temperature when burning producer gas will approximate 1100 to 1250 deg. F., when burning coke-oven gas, it will run 100 to 200 deg. lower. These temperatures were found on the same furnace. A reduction in the size of the openings between the checker brick reduced the stack temperatures very perceptibly when coke oven gas was being burned. Where conditions are such that a furnace may be called upon to burn either gas, it is necessary, when burning coke-oven gas, to mak esome provision to supply air to the two regenerators through which the gas passes, when producers are in service. This air is supplied by a small fan suitably connected to the regenerator openings by piping with appropriate arrangements for reversing.

It might be expected that a change from the highly luminous producer gas to the faintly luminous coke-oven gas would introduce a disturbing element in the operation of the furnace. Such fortunately has not been the case, but on the contrary furnace men have shown a partiality to the less luminous coke-oven gas. Due to economic reasons it is not advisable to burn coke-oven gas under boilers, but in some plants a certain portion must be thus consumed. Most plants aim to keep this portion below 10 per cent of the amount available.

Electric Equipment for Steel Plants

Progress in the Design and Construction of Motors for Driving Mills of Various Types Is Presented—Equipment for Mills at Various Steel Plants Given in Detail

By A. F. KENYON*

THE severe operating conditions, the necessity for uninterrupted service over long periods of time, the requirement for flexible and easy control of the large powers involved in rolling mill drives, combine in their demand for developments in electrical equipment which have hardly been equalled by any other group of industries. The keen competition for business has forced rolling mill operators to carefully analyze and study their operating costs with the result that many of the wasteful steam engine driven mills have been replaced by modern motor driven mills of improved economy and increased capacity. In laying out new mills or modernizing existing units, it has, in many cases, been found easily possible to eliminate one or more men from the operating crew, thus effecting a considerable saving in yearly operating costs. The so-called "tandem" type of mill, with individual motor drive of the several finishing stands, is now being extensively used for rolling strip, rod, and merchant and small structural shapes, and is well suited for this class of work, as the close spacing of the stands and the high operating speed permit finishing the section at relatively high temperatures with correspondingly lower energy consumption. The flexibility obtained by individual adjustable speed drive for each finishing stand is very desirable as it allows wide latitude in the making up of rolling schedules, and also permits rolling at higher delivery speeds and with fewer cobbled bars.

The past year has witnessed the placing in regular operation of the largest single unit d.c. reversing mill motor yet built as the drive for a 54-in. blooming mill. This huge machine has a rated continuous capacity of 8,000 hp., 50 deg. rise, at speeds between 40 and 80 rpm.; and at speeds up to the base speed of 40 rpm., it is capable of exerting a maximum emergency torque of 2,500,000 pound-feet. Direct current power at 700 volts is supplied from a flywheel motor generator set consisting of two 3500-kw. generators operating in parallel, a 150,000-lb. cast steel flywheel, and a 5,000-hp., 3-phase, 25-cycle, 6600-volt, 368-rpm. wound rotor induction motor.

The above reversing motor equipment is part of an installation of electrical drives which is outstanding in that the individual units are the largest of their type yet built and also in that the total continuous capacity of 38,000 hp. of reversing motors is greater than that of any other plant in the world. The drives are as follows:

44-in. blooming mill—7,000-hp., 50/120-rpm. reversing motor.

36-in. roughing structural mill—5,000-hp., 50/120-rpm. reversing motor.

32-in.-28-in. finishing structural mill—6,000-hp., 99-rpm. induction motor.

54-in. blooming mill—8,000-hp., 40/80-rpm. reversing motor.

52-in. roughing structural mill—7,000-hp., 50/120-rpm. reversing motor.

52-in. roughing structural mill—2,000-hp., 57/163-rpm. reversing motor.

52-in. intermediate structural mill—7,000-hp., 50/120-rpm. reversing motor.

52-in. intermediate structural mill—2,000-hp., 57/163-rpm. reversing motor.

Each of the above seven reversing mill motors is built as a single unit machine, and is supplied with power from a motor generator set having two d.c. generators operating in parallel. The slow speed reversing motors may be advantageously built as single armature machines, as the efficiency is higher, and the inertia of rotating parts is less than of a double armature machine of similar capacity. A system of connections has been developed which insures the equal division of load between the paralleled generators and thus permits the use of the more desirable single unit reversing motors, even in the largest sizes.

A large manufacturing company has greatly increased its steel finishing capacity by the recent installation of a 40-in. reversing blooming mill and a combined universal plate and cross-country type of merchant and structural mill. The 40-in. blooming mill is driven by a 7,000-hp., 50/120-rpm., 700-volt, single unit reversing motor, which at the time of its installation was the largest single armature machine to be placed in service, but whose capacity has since been exceeded by the 8,000-hp. motor mentioned in a preceding paragraph.

The 27-in. universal plate mill and the roughing stand of the structural and merchant mill are driven by a 3,100-hp., 70/150-rpm., 600-volt, reversing motor, while the five stands of the 24-in. cross country mill are driven by three 2,000-hp., 230/460-rpm., 700-volt, d.c., adjustable speed motors. Power for the 3,100-hp. reversing motor and for the three 2,000-hp. motors is supplied by a flywheel motor generator set consisting of a 6,500-hp. induction motor, a 100,000-lb. cast steel flywheel, and two 3,000-kw., d.c. generators. By the use of a flywheel set for supplying power to the four drives, the peak demands from the power system are greatly reduced from what would be the case if synchronous sets were used in connection with the 2,000-hp. drives.

An interesting feature of the cross country mill auxiliaries is the very extensive use of automatic control and the interlocking of the various movements. Flag switches located in front of the roll stands function to stop the tables as soon as the steel runs out and to start the transfer which carries the steel to the entering position before the next stand. Here the transfer is stopped by limit switches and the table started to enter the metal in that stand. This automatic operation of the auxiliaries permits operation of the cross country mill with a very small crew in the pulpit, and also greatly expedites rolling so that production is increased and the steel finished at higher temperatures with consequent lower energy consumption.

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Recently there has been developed a new type of a.c. adjustable speed equipment having constant torque characteristics and capable of double range operation, that is, either above or below the synchronous speed of the main induction motor. A frequency converter, mounted on the same shaft with the main induction motor, is the only auxiliary rotating machine required. The slip energy of the induction motor is converted to line frequency by the frequency converter and thence returned to the power system through speed adjusting transformers. In addition to the two main windings, the transformers have tertiary windings for the purpose of improving the power factor of the equipment. This type of adjustable speed equipment is much simpler in construction than previous types, fewer auxiliary machines are required, and the performance is considerably better.

Producers of strip steel were the first to appreciate the flexibility and ease of operation of the so-called "tandem" type of mill, in which each of the several finishing stands is driven by an individual adjustable speed motor. One of the largest and most modern of such strip mills is the 20-in.-16-in. mill placed in operation during June, 1926, at the plant of the Acme Steel Company, Riverdale, Ill. This 14-stand mill has electrical drives as follows:

One 1,500-hp., 705-rpm., 3-phase, 60-cycle, 2200-volt, wound rotor induction motor, for roughing stands 1, 2, 3, 4, 5, and 7.

Two 100-hp., 360/900-rpm., 600-volt, d.c., adjustable speed motors, for vertical edging stands 6 and 8.

One 1,500-hp., 200/400-rpm., 600-volt, d.c., ad-

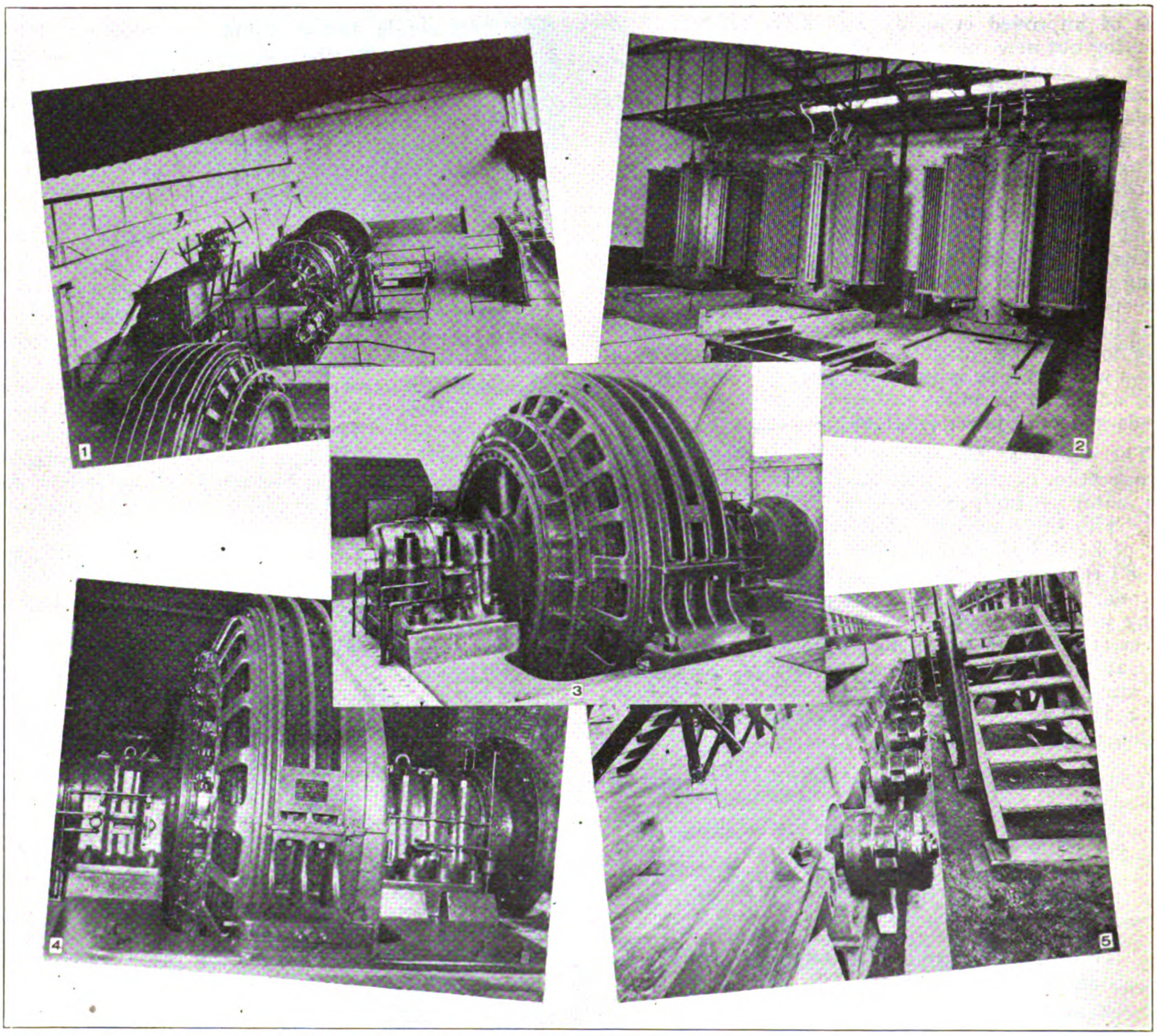

FIG. 1—7000-hp., 50/120-rpm. reversing motor, driving 40-in. blooming mill with motor-generator set. FIG. 2—Three 3333-kv-a., 12,000 to 2300-volt, 60-cycle transformers supplying power for the Acme Steel Company strip mill. FIG. 3—5000-hp., 50/120-rpm. reversing motor driving a 40-in.blooming mill at Sagunto, Spain. FIG. 4—3500-hp., 50/120-rpm. reversing motor for the Kokomo Steel & Wire Company 34-in. blooming mill. FIG. 5—Hot bed runout table with individual motor drive at the Acme Steel Company hot strip mill.

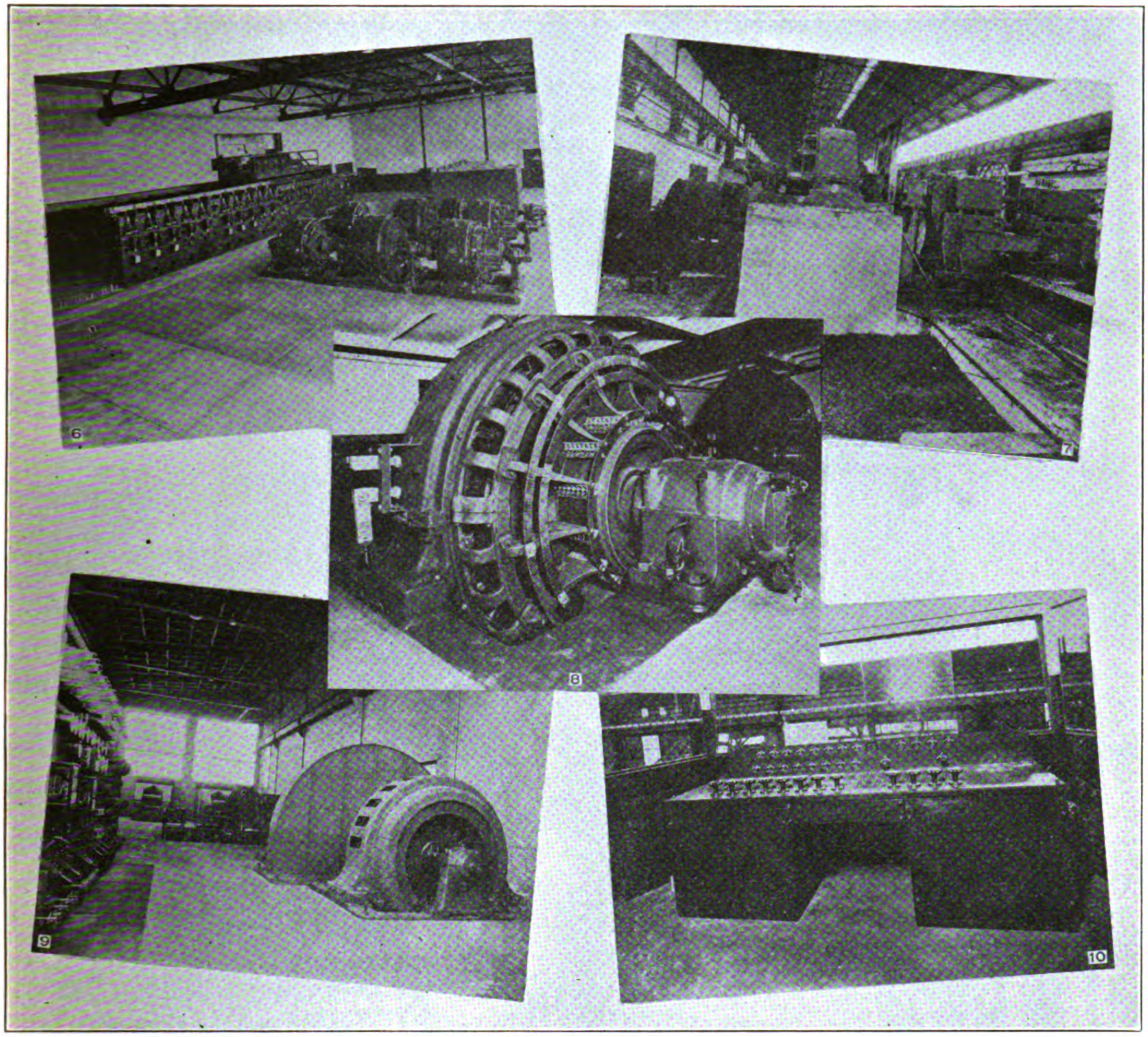

FIG. 6—Motor room and substation for the Acme Steel Company strip mill. FIG. 7—100-hp., 360/900-rpm. motor driving edger for the Acme Steel Company strip mill. FIG. 8—1800-hp., 185/370-rpm., d.c. motor geared to strip mill at the Acme Steel Company. FIG. 9—36-in. blooming mill substation at Phoenix Iron Company showing 3500-hp. reversing motor. FIG. 10—Desk for control of motor generator sets and roll motors at the Acme Steel Company.

justable speed motor, geared to intermediate stand 9.

One 1,800-hp., 185/370-rpm., 600-volt, d.c., adjustable speed motor, geared to intermediate stand 10.

Two 1,800-hp., 125/250-rpm., 600-volt, d.c., adjustable speed motors, direct connected to finishing stands 11 and 12.

Two 1,800-hp., 185/370-rpm., 600-volt, d.c., adjustable speed motors, direct connected to finishing stands 13 and 14.

Direct current power at 600 volts for the operation of the edging, intermediate, and finishing stand motors is supplied by two 2,000-kw., three-unit synchronous motor generator sets, and 250-volt d.c. for excitation and for auxiliary power is supplied by a 650-kw. synchronous set. Starting of the six intermediate and finishing stand motors is by means of generator voltage control, all operations except starting the motor generator sets being performed from a control desk in a balcony overlooking the mill.

Power for the operation of this mill is purchased at 12,000 volts, 3 phase, 60 cycles, and is stepped down to 2,300 volts by a bank of three 3,333-kv-a., self-cooled transformers, in a transformer room adjacent to the main motor room and substation. All oil circuit breakers, both 12,000 and and 2,300 volt, for the control of incoming lines, main, auxiliary power, and lighting transformers, roughing mill motor, and motor generator sets, are of the safety enclosed, truck-mounted type, complete with steel cell housings.

Ventilating air for the d.c. motors and the motor generator sets is provided by two 60,000 c.f.m. blowers which draw the air through dry type filters and discharge it into the motor room basement. Cored openings in the machine foundations permit the clean air to pass up through and around the machines.

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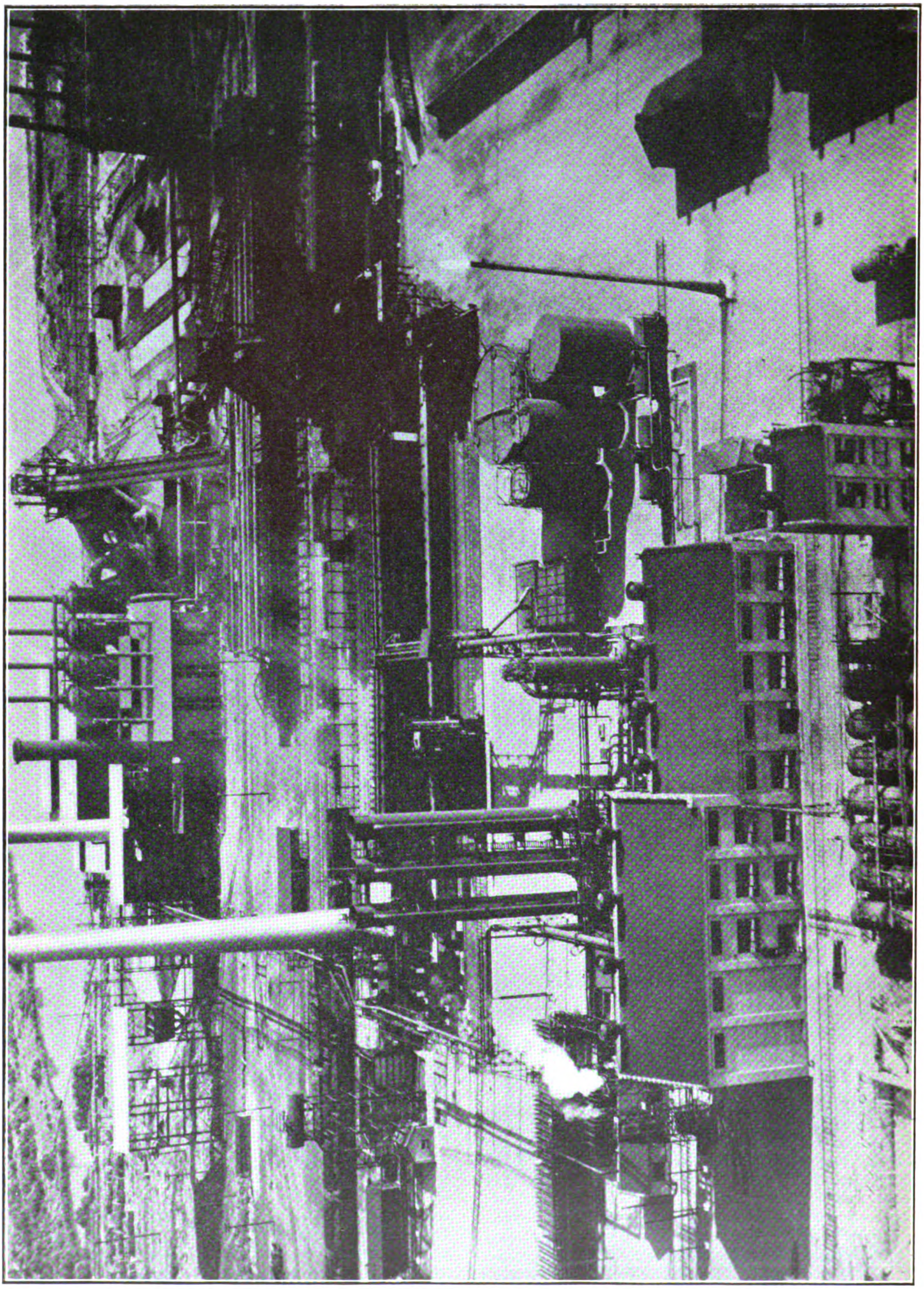

Fifty-seven Koppers-Becker type ovens at the by-product coke plant of the Republic Iron & Steel Company, Birmingham, Ala.

By-Product Coke and Gas Industry

Tendency Toward the Installation of Ovens of Larger Capacity Is Evident—Gas Companies Distributing Gas from By-Product Ovens Fired with Producer Gas

By C. J. RAMSBURG*

THE year 1926 saw America's coke productive capacity increased by more than 9,000,000 tons per year in the plants installed by the by-product coke industry and the gas industry.

As in previous years, most of the additional capacity was provided by combination type ovens. The specialized uses for oven gas that are constantly arising in the steel industry, are drawing much attention to this type of plant which may be heated with producer gas or blast furnace gas to release oven gas that would otherwise be used for heating.

The trend of the industry is still for larger unit coke oven capacity. The ovens of the Carnegie Steel Company at Clairton, Pa, which are now under construction, have individual capacities of 19.13 tons per charge. Three hundred and forty-eight of these ovens are under construction for the Carnegie Steel Company and will increase the capacity of its Clairton Coke Works, which is already the largest by-product coke plant in the world, by some 3,900,000 tons per year.

Significant of the attitude of gas companies serving large cities was the completion, late in 1926, of a by-product coke plant for the Consolidated Gas Company of New York. This plant, which consists of 74 ovens, will have a daily capacity of nearly 2,000 tons of coal, and a gas make of 20,000,000 cu. ft. per day. It is interesting to note that the release of all oven gas for outside uses was only possible by taking advantage of the ability of these ovens to be underfired with producer gas.

A plant which is under construction for the Michigan Alkali Company is an interesting example of the application of the merchant coke plant idea to a company not directly engaged in the steel industry. This company requires a steady supply of high quality coke but, having no extended use for gas within its own plant, must market the gas to assure the economical production of its coke.

PLANTS PLACED IN OPERATION DURING YEAR

Company	Location	No. of Ovens	Type of Ovens	Estimated Annual Cap. Tons of Coke
Illinois Steel Company	Gary, Ind.	138	Koppers-Becker	881,475
Rochester Gas & Electric Corporation	Rochester, N. Y.	38	Koppers-Becker	114,720
Jones & Laughlin Steel Corporation	Aliquippa, Pa.	122	Koppers-Becker	770,000
Jones & Laughlin Steel Corporation	Hazelwood, Pa.	60	Wilputte	307,000
Inland Steel Company	Indiana Harbor, Ind.	73	Koppers-Becker	434,650
Indiana Coke & Gas Company	Terre Haute, Ind.	30	Koppers	140,000
Consolidated Gas Company	New York City	74	Koppers-Becker	447,125
Utica Gas & Electric Company	Utica, N. Y.	21	Koppers-Becker	73,000
Wheeling Steel Corporation	Follansbee, W. Va.	51	Koppers-Becker	242,900
Weirton Steel Company	Weirton, W. Va.	49	Koppers-Becker	306,600
Rochester Gas & Electric Corporation	Rochester, N. Y.	23	Koppers-Becker	77,000
PLANTS UNDER CONSTRUCTION AT DEC. 31, 1926				
Central Furnace Company	Massillon, Ohio	49	Koppers-Becker	306,600
Republic Iron & Steel Company	Youngstown, Ohio	43	Koppers-Becker	280,350
Bethlehem Steel Company	Johnstown, Pa.	77	Koppers-Becker	399,000
West Boston Gas Company	Framingham, Mass.	15	Koppers-Becker	32,250
Tennessee Coal, Iron & R.R. Company	Fairfield, Ala.	63	Koppers-Becker	459,900
Diamond Alkali Company	Painesville, Ohio	23	Koppers-Becker	158,900
Carnegie Steel Company	Clairton, Pa.	348	Koppers-Becker	2,721,000
Bethlehem Steel Company	Lackawanna, N. Y.	57	Koppers-Becker	364,000
Consumers Power Company	Flint, Mich.	29	Koppers-Becker	94,850
Alabama By-Products Corporation	Birmingham, Ala.	49	Koppers-Becker	350,000
Trumbull Cliffs Furnace Company	Warren, Ohio	17	Koppers-Becker	113,400
New England Fuel & Transportation Co	Everett, Mass.	55	Wilputte	275,000
Ford Motor Company	Detroit, Mich.	90	Wilputte	615,000
Hamilton Coke Ovens, Ltd.	Hamilton, Ont.	30	Wilputte	134,000

There is a definite tendency of all companies requiring large quantities of high grade coke to produce coke in their own by-product ovens. In many cases, however, the lack of applications sufficient to consume all of the gas produced shuts them off from doing this. More fortunately situated are those companies which are able to dispose of their surplus gas to gas companies for domestic distribution. With but few exceptions such companies as these are engaged in operations in or allied with the steel industry.

It is noteworthy that the new capacity placed under construction or in operation in the year 1926, was over 18 per cent of the total American by-product capacity at the close of 1925.

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*Vice President, The Koppers Company, Pittsburgh, Pa.

Survey of Power Plant Developments

Steam Turbine Grows from 5,000 to 280,000 Horsepower—Boiler Drums Now Forged—Firing of Powdered Coal Develops Along Lines Predicted

By F. J. CROLIUS

NINETEEN hundred and twenty-six has been an important year in power plant development. While nothing startling new, except the massive size of projected units, has come to light, the general tendencies exhibited during 1925 have been cemented into definitely accepted practice for this year and the immediate future.

The General Electric Company's announcement of a turbine unit with a capacity of 280,000 hp. for the Chicago super-power zone seems to suggest a climax to a year of great progress.

We remember very vividly back in 1902 when Charles T. Yerkes had given the Westinghouse Company a contract for 5,000-hp. Parson's turbines to supply power for the electrification of the London Underground Railways. "Five thousand horsepower in a single turbine"—every one assumed that it couldn't be done.

A glance about the floor of the Westinghouse shop at East Pittsburgh would have nearly convinced a visitor that current skepticism was justified—turbine casings and rotors were everywhere. But the then "huge engines" were completed and delivered.

Today we accept 280,000 hp. announcements as merely casual.

Even the railroads—last to accept innovations—are now overwhelmed with experimental testing work which will indicate to them their possible choices for their various characters of service; never before could they select from a variety of high-pressure steam locomotives, including water-tube fire boxes, from Diesel or gasoline, from Diesel or gasoline electric combinations—from fireless boilers, from storage battery machines.

Paralleling these adaptations to land transport, we find the marine field passing through the same stage. Expressing the latest effort to put marine Btus. to work, a glance along the Clyde is illuminating.

The trial run of the King George V is heralded with the following headlines:

"STEAM'S REPLY TO THE CHALLENGE
OF THE DIESEL
High Pressure Turbines for Ship Propulsion—Coming of a New Era in Marine Engineering"

Narrow boilers with straight tubes expanded into forged drums generate steam at 550 lbs. pressure, superheated to a final temperature of 750 deg. F. These boilers incorporate an economizer section and air-preheaters take the single pass combustion products directly to the stacks.

Total steam generated at 750 deg. is taken by the single high-pressure Parson's turbine which exhausts at 200 lbs. pressure. The high-pressure turbine develops approximately 16 per cent of the total horsepower. The intermediate turbines operate at this lower pressure. All turbine blading is monel metal.

Method of Building Boiler Drums.

A large octagonal ingot of ordinary boiler plate steel is forged under a hydraulic forging press to a round billet. It is then cut to a length which will give the weight necessary for the finished forging, and is carefully examined for surface defects. A hole is bored throughout the entire length of the billet large enough to take a mandrel for the second forging operation.

The second forging operation consists in expanding the billet to a larger diameter without increasing the length; the internal diameter after this operation is slightly less than the finished diameter of the steam drum. The forging is reheated for the third operation.

This operation consists in forging on a mandrel so that the length is increased without increasing the diameter. A large mandrel of a diameter approximately that of the finished drum is used; forging is continued until the required length is attained.

The thickness of the steel section is now that required for the drum, plus machining allowances.

The ends of the forging are left thicker to allow for the final operation, which takes place after the inside of the drum is bored to finished sizes.

The last forging process consists in closing in both ends. The final closing in is performed on a round bar or mandrel somewhat smaller in diameter than the manholes in the drum-heads.

The forging is then thoroughly annealed and sent to the machine shops, where the necessary physical tests were made and the final machining accomplished. Test pressure was 913 lbs.

The boiler drums installed at Weymouth, Mass., followed similar practice. The Midvale Company built these to operate at 1200 lbs. pressure.

And the steel industry has felt the self-same impulses. The steel works power plant is being reborn. It resembles in very remote way the "boiler house and engine" combination which kept everyone busy during the war and before.

It might be interesting to turn back the pages of operating records and engineering discussions and compare what we find with 1927.

Powdered coal was in its swaddling clothes 10 years ago. A few of us had gone through the grief of early experiment with very crude devices (Fig. 1 shows an early Ball mill), but had determined that the flexibility and ultimate firing cost of this method of burning solid fuel must survive when proper equipments were devised to meet the new conditions.

The following is taken verbatim from a paper delivered before the Association of Iron and Steel Electrical Engineers, which organization was among the earliest in recognizing this solution to an important phase of their power problem:

> If we look back 20 years we find a 250-hp. water tube boiler considered mammoth. And if we attempt to measure the size of the "combustion chamber" we will find a micrometer necessary—there was no combustion chamber as we now understand one.
>
> Today we design a combustion chamber and then build a boiler around it. (Witness the Combustion Engineering Com-

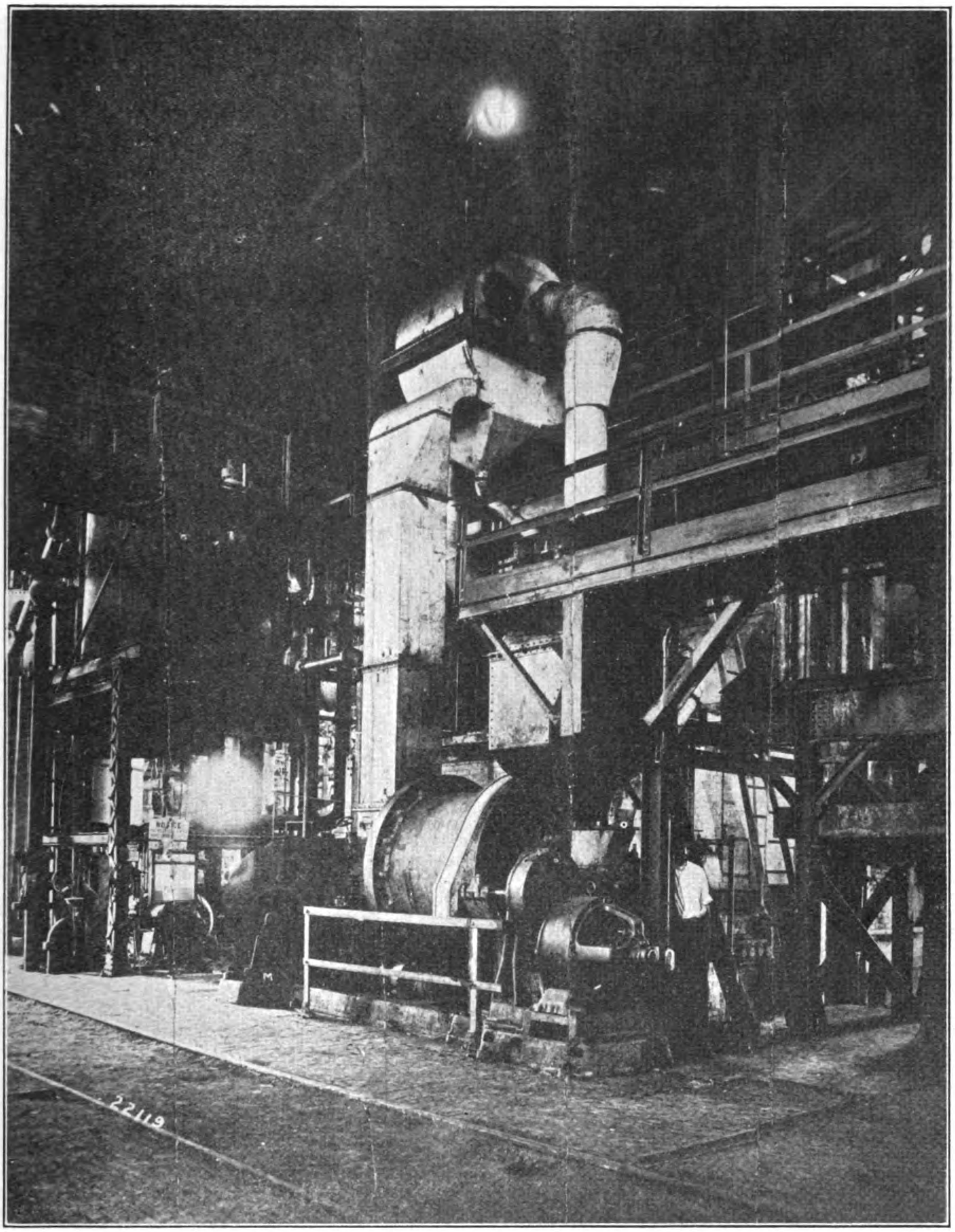

FIG. 1—A view taken shortly after this large ball type mill was put into service in a large steel mill, "direct firing" a B. & W. boiler. This installation was one of the early experiments in this method of combustion. Efficiencies were very satisfactory.

pany's new type steam generator, since developed.)

The operating conditions which resulted in failure were definite—slagging upon tubes, destruction of brickwork, cost of maintenance, and expense of installation. (Witness the various types of air-cooled walls, fin tubes and water screens now employed.)

* * * * *

Many engineers have attacked their problem in different ways, but the result of these various lines of attack have developed into two schools of pulverized operation, (a) the indirect or centralized preparation plant, (b) the direct fired.

The indirect method was the logical first step in the application of pulverized fuel under boilers—it presupposes the existence of pulverizing equipment already delivering pulverized fuel for some metallurgical purpose in a plant—and the *extension* of this pulverized fuel to boilers already existing.

In this method the coal is usually prepared in a central pulverizing plant, conveyed to the boiler house and distributed to the boiler furnaces. Drying is essential to distribution.

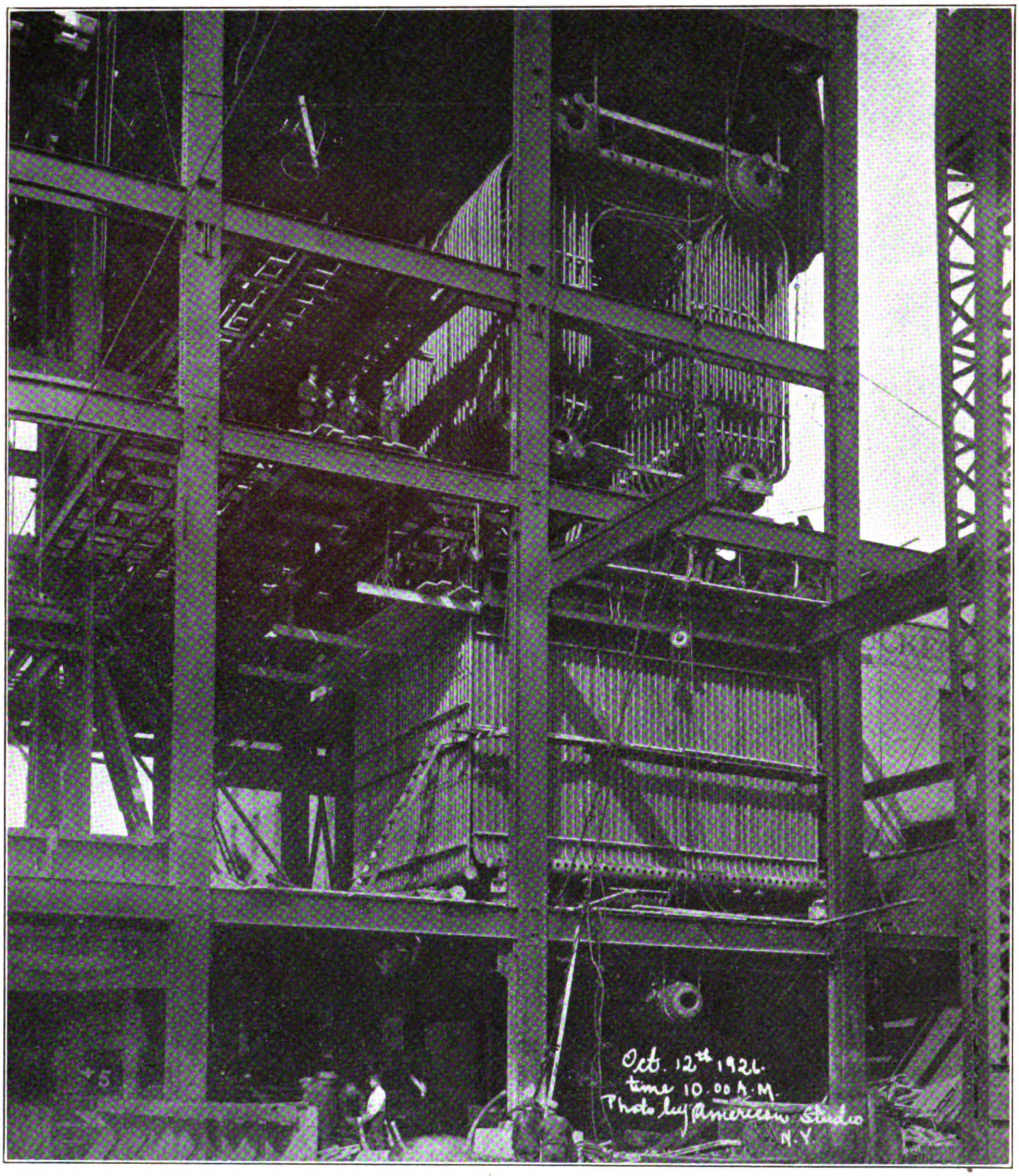

FIG. 2—One of the largest boilers yet constructed, capacity of approximately 325,000 lbs. steam per hour. The picture was taken during erection, and before the brick work was in place; in no other way could the details be observed. This huge boiler—one of three—similar, was erected and put into service within 197 days. It is of the Ladd type with Combustion Engineering Company fin-tube firebox, shown beneath.

Direct Method.

In the direct method of pulverized application to boiler firing, the pulverizer is placed directly at the boiler, the existing raw coal handling equipment is utilized, the coal is fed to the pulverizer *undried,* and is exhausted directly into the boiler furnace or combustion chamber. There is *no hazard* from driers, no hazard from bins, back-fires from momentarily unbalanced pressures; there is "no storage of gunpowder," to quote Sam Wales.

The burner and ignition problem is the same in both methods, but the direct method is more susceptible of automatic regulation. Such is now applied.

The Aero pulverizer has been largely used in direct firing. The Hagan combustion control has been applied to this.

Comparatively little development work along direct firing of boilers has yet been attempted. The most obvious reason, in my mind, has been the subconscious thought that pulverized firing was a very mysterious and difficult engineering feat—and not to be attempted without spending a company fortune.

It may be that suitable equipment has not been available, or the fact was not known that 95 per cent 200-mesh *dried* coal was not needed.

Numerically the small boiler demands attention, for more steam is still being produced in small boilers than in large boilers; expressed in round numbers, some 100,000,000 tons of coal are consumed in small, low-efficiency plants, as against 75,000,000 tons annually in large boilers—and the comparison of cost between them stands safely at a 3 to 1 ratio against the small plant.

Here then is the immediate field for pulverized application —for, remarkable as it may seem, the actual efficiency obtainable in *any size* boiler, using any kind of coal, varies but slightly, when the setting is properly proportioned. The small boiler can be made as efficient as the large.

* * * * *

Analysis showed that these ten 1,000-hp. boilers (stoker fired) could be re-equipped to produce the total evaporation required to operate these mills, and the savings would warrant whatever type of pulverizing equipment this 17,000-hp. production demanded.

Further analysis of the factors comprising the charges against coal and ash-handling from the yard to the yard (including the firing cycle) may be of interest when shown against comparison of like charges with pulverized equipment:

	Former	Pulverized
Yard switching	$ .22	$ .22
Coal unloading and distribution	.23	.03
Firing	.17	.01
Ash-handling	.26	.02
Repairs to equipment	.10	.07
Power stokers, hoists, conveyors	.105	.00
Power pulverizers, exhausters ,etc.	.00	.22
	$1.085	$ .57

You can all figure the saving effected by multiplying 200.000 tons x $0.51.

* * * * *

The factors governing combined efficiency are always in favor of pulverized firing; intimate admixture of a minimum excess and with a maximum fuel surface for the combustion reaction; *both* the fuel and air under careful regulation, irrespective of the length of hours the boiler has been in service; high temperature surrounding the zone of ignition, no cleaning periods, with consequent chilling of the furnace and boiler; lowest up-stack losses due to dilution, lowest loss due to unburned carbon-monoxide; no ash-pit losses; simpler application of preheated air.

Pulverized firing inherently possesses all the advantages of the modern forced draft stoker; many advantages not possessed by *any stoker,* but *without* the disadvantages of most of them.

Any type of boiler is susceptible of this development, provided adequate combustion chamber can be installed, but the ideal type of *super-boiler* is still in the future.

* * * * *

When we add to the many obvious advantages the definite availability of preheated air through a direct firing pulverizer, a mere transposition of the two temperature symbols in the up-stack loss formula—an application very difficult in stoker installations, but entirely practical in pulverized installations, we visualize possibilities of not 80 *per cent* efficient, but nearer 90 *per cent* efficiency.

This would be ideal.

From the foregoing it can be seen that controversy was then raging as to the method of handling the total problem. The advocates of central pulverizing systems scorned the thought of any competition from "unit systems." The operators of unit installations were firm in the belief of the prosaic story told by their operating cost sheets. It is hard to argue against the facts, when expressed in dollars for and against.

A visit to the Power Show in New York during December emphasizes the story of ten years' progress. It seemed as though every booth was demonstrating a different type of "unit system."

Today no engineer would hazard laying out a modern power house without first considering its possibilities in terms of powdered fuel.

And as with methods of firing solid fuels, so has it been with steam quality.

Ten years ago very little thought was given to steam quality; a certain amount of moisture was taken for granted, even though practically all manufacturers' catalogs exhibited tests proving "commercially dry steam." Clean steam never entered the discussion.

Superheaters were installed to overcome this moisture condition, with little thought that such work did not belong among the proper functions of a modern superheater; theoretically a superheater is designed to receive clean, dry steam, and raise its temperature normal to the pressure vessel to some predetermined higher level. But to accomplish this any superheater must be maintained with heat exchanging surfaces clean inside and out.

With many characters of water, even though they be carefully and correctly "treated," keeping superheaters clean internally is a very difficult matter where moisture and solids are allowed unrestrained flow from the boiler nozzle to the superheater.

Then a genius moved the steam separation problem away from the conventional line separator ahead of the unit and placed it where it properly belonged within the boiler shell at the very portal of the steam's issuance and thus gave birth to the internal steam purifier.

Some have confused the steam purifier as a dry pipe which was, and still is, in many cases an historical part of a boiler—particularly a water tube boiler.

But the properly designed steam purifier is as far removed from the category of a dry pipe as the dry pipe is from perfectly dry, clean steam. To be a purifier, except in name only, the internal fixture must purify the steam by removing not only the moisture, but more important, the chemical solids which concentrate within the boiler water and which must leave with the steam.

No one assumes that a dry pipe can do this, and from the principles involved in the design and structure of a dry pipe it is improbable to expect it to so function.

Several Methods Employed.

No simpler nor more effective force exists for the classification and separation of minute particles of different specific gravities, when these particles are in a state of suspension in a carrier current—than centrifugal force.

The application and control of the force for this or any specific problem remains, however, a matter of intense scientific research.

The early suggestions and experiments which indicated the practical adaptation of centrifugal force to the improvement of steam quality—the application taking the form of an internal purifier met with about the same enthusiasm as the early experiments with pulverized fuel. "It simply can't be done," was the verdict.

Reference again to this year's Power Show indicates that it has been done and done so well that 1927 finds the steam purifier an accepted part, a most vital part, of the modern high-tension boiler or steam generator.

And as with turbines versus reciprocating engines, pumps, compressors, blowers, as with methods of firing solid fuels—hand, stoker, pulverized, as with low temperature unrefined steam versus highly superheated steam cleansed of its abrasive chemical solids, out of bitter controversy has come progress.

So great and rapid has this progress taken place within the special field of power and so vitally does it affect the life and well-being of every one of us, that the statistics recording the kilowatt production are now accepted as one of our surest indicators of national affluence.

The Steam Engineer's Contribution to Metallurgical Combustion

In concluding this brief outline of the tendencies which have emphasized themselves during the year, it may be not ungenerous to quote verbatim the thoughts expressed by one whose achievements have meant much to this industry.

"The efficient use of fuel in the large boiler plants of this country, is no longer dependent upon the human element," says J. M. Hopwood. "Automatic Systems of Combustion Control have demonstrated their merit and it is safe to say that millions of dollars are being saved annually in the production of steam by the use of this apparatus.

Why has the steel industry so far failed to recognize the potential possibilities of similar apparatus in connection with the production of steel?

"The fuel savings possible in the metallurgical field are enormous, but of far greater importance is the assurance that the product would be greatly improved and the losses due to oxidation, etc., materially reduced by the automatic maintenance of conditions that are correct for each type of furnace or class of product.

"There is no question as to the availability of the necessary apparatus, and steel mill superintendents interested in improving the combustion conditions in the heating furnaces, can probably find operating in those boiler plants, regulating equipment that would work wonders for them if they would recognize the necessity for it.

"It is a mistake to look upon the combustion problems involved in the operation of metallurgical furnaces as more difficult of solution than those encountered in big boiler plants. In fact a casual study of an up-to-date boiler house utilizing powdered coal, air preheaters, forced and induced draft, primary and secondary air admission, etc., will disclose a combustion problem of greater magnitude than is encountered in any steel mill furnace.

"A striking example of what automatic apparatus can accomplish, is furnished by a number of plants where the burning of blast furnace gas under stoves and boilers, has been given serious consideration from an automatic control standpoint.

"Simple apparatus continuously and automatically proportioning the air to the gas available, has increased the efficiency from 15 to 40 per cent, and resulted in savings that are almost unbelievable.

"Steel plant engineers are certainly justified in giving this important question careful consideration, both from the standpoint of fuel saving, superiority of products and reduction in furnace maintenance cost."

Electrical Equipment for Steel Plants

(Continued from page 39)

A 34-in. blooming mill at the plant of the Kokomo Steel & Wire Company at Kokohom, Ind., and a 36-in. blooming mill at the plant of the Phoenix Iron Company at Phoenixville, Pa., have each been electrified. The drive for each mill consists of a 3,500-hp., 50/120-rpm., 700-volt, d.c. reversing motor, supplied with power from a flywheel motor generator set made up of a 3,000-kw. generator, a 60,000-lb. flywheel, and a 2,500-hp., 353-rpm., 3-phase, 60-cycle, 2200-volt wound rotor induction motor. An unusual feature of the Kokomo installation is the large flexible coupling used in preference to a universal or crab coupling to connect the motor shaft to the pinion stand.

The usual voltage ratings of main machines in rolling mills are 2,200 and 6,600, and until recently higher voltages than 6,600 have not been used as it was thought that the higher voltages would aggravate any troubles with insulation caused by the conducting dust prevalent in steel plants. One plant has, however, adopted 13,200 volts for all main machines, and has recently installed a 5,000-hp., 99-rpm., 3-phase, 60-cycle, wound rotor induction motor of that voltage rating as the drive for a continuous billet mill. Due to the slow speed the motor is of unusually large diameter.

At the plant of the Inland Steel Company, Indiana Harbor, Ind., a 7,000-hp., 50/120-rpm., single unit reversing motor was installed on a 36-in. blooming mill to replace a steam engine. Schedules were such that the mill could be shut down for but a very short time to accomplish the change-over. The work was therefore pushed with all possible speed with the result that six days and three hours after the last ingot had been rolled by steam power, the mill was again in operation with electric drive.

The Forged Steel Wheel Company at Butler, Pa., are electrifying their 40-in. blooming mill by the installation of a 7,000-hp. single unit reversing motor equipment.

Of considerable interest is the new 10-in. tandem strip and merchant mill now being installed by the Laclede Steel Company at Alton, Ill. The five main drive motors are as follows:

One 1,500-hp., 198/400-rpm., 600-volt, d.c. motor, for the continuous roughing mill stands 1 to 6.

One 600-hp. 185/470-rpm., 600-volt, d.c. motor, direct connected to stand 7.

One 600-hp., 270/635-rpm., 600-volt, d.c. motor, direct connected to stand 8.

One 720-hp., 395/825-rpm., 600-volt, d.c. motor, direct connected to stand 9.

One 720-hp., 480/1000-rpm., 600-volt, d.c. motor, direct connected to stand 10.

Direct current power for the operation of the above motors is supplied from a synchronous motor generator set consisting of two 1,250-kw. generators, and a 3,700-hp., 100 per cent power factor, 3-phase, 60-cycle, 2,200-volt synchronous motor. A split bus system is used, the 1,500-hp. motor and one 1,250-kw. generator being connected to one section, and the four 600 and 720-hp. motors and the other 1,250-kw. generator being connected to the second section of the bus.

This mill will be operated at delivery speeds up to approximately 2,700 ft. per minute, and it is expected to use billets up to 30 ft. long, so that it is very necessary that the finishing stand motors have practically flat speed regulation from no-load to full-load at any speed within the speed range. The motors are therefore fully compensated, and are of the separately excited, compound wound type. The separately excited series fields are energized from the armature of a small exciter generator whose field is excited by the main motor armature current.

THE STEEL PLANT BRICK MASON

A section devoted to items of general interest to blast furnace and steel plant brick masons.

Thirty-one Years as Brick Mason

The subject of this sketch, Henri Rateau, started work at the age of 12, as a laborer in the steel mills of Canada. He was placed with the brick masons, where he showed such a liking for the work that he was raiseld to a mason in the "gang." Some years later he became foreman.

For 16 years Mr. Rateau had charge of brick construction for the Nova Scotia Steel Company, while in later years he worked in a similar position for the Dominion Iron & Steel Company. In coming to the United States, he found employment in the open-hearth department of the Mansfield Sheet & Tin Plate Company at Mansfield, Ohio.

Henri Rateau, second from right, superintending brick work at the Weirton Steel Company's new blast furnace and boiler house.

Mr. Rateau is now and has been for the past a very busy man. He has been in active charge of the entire brick work job at Weirton's new furnace and boiler house, which merely means that the 125 or more men in the Anderson Company gangs have had to put in place 650,000 9-in. equivalent bricks in the furnace, some 1,500,000 9-in. equivalent in the stoves, and several thousand required in the boiler settings.

Refractory Publications

High Temperature Cement—The General Refractories Company, Philadelphia, Pa., are distributing a booklet entitled "Grefco," describing a new chrome base high temperature cement. This cement possesses great refractoriness and resistance to metallurgical slags and fusible coal ash. The properties and uses of the cement are fully described and illustrated.

Refractories—Refractory brick for hard use, made from diaspore deposits in Missouri, are featured in a bulletin by the A. P. Green Fire Brick Company, Mexico, Mo. Much attention is paid to describing the raw material and its characteristics and the resulting bricks are presented as to their adaptability.

* * *

Refractory Materials—Botfield Refractories Company, Philadelphia. Pamphlet containing reprints of letters telling of successful installations of the companys' Adamant fire brick cement with numerous descriptive photographs.

* * *

Refractory Materials—Ashland Firebrick Company, Ashland, Ky. Illustrated circular briefly touching on the essential characteristics of the company's various types of fire brick.

The Refractory Question Box

The Blast Furnace and Steel Plant Brick Mason will be glad to answer questions of a practical nature on the use of refractory materials in general steel mill practice. Questions pertaining to any particular brand of refractory will be answered.

Brick Mason,
The Blast Furnace and Steel Plant,
Pittsburgh, Pa.
Dear Sir:

We have had some trouble with our brick work in certain furnaces due to the mortar used in laying the joints giving away. What is the best practice as to the mortar or cement used in laying clay brick and silica brick?

Yours very truly,
C. N. B.

Answer—The general opinion among leading Brick Superintendents is that a mortar made of ground clay of the same composition as the brick gives the best results.

The opinion in laying up silica brick is to use a mortar made of silica cement, the same composition as the brick, mixed with a quantity of high grade fire clay. There are various opinions regarding the per cent of fire clay and ground silica brick to be used in the mixture of "Silica Cement." The opinion is based on the use and runs from a 50-50 mixture.

The Hiram Swank Co., Johnstown Pa., report gratifying activity in the sale of both shapes and standard sizes. Besides the shapes, for which the company has acquired an enviable reputation, the manufacture of checker brick and straight nine-inch are absorbing a high percentage of plant capacity.

TRADE NOTES

A. G. Heggem, 303 West Sixth Street, Tulsa, Okla., is at the head of a project to construct and operate a new iron and steel works at Sand Springs, Okla., to cost close to $500,000 with equipment.

* * *

The Cleveland Atomized Fuel Company, Cleveland, has acquired the plant formerly occupied by the Ohio Briquetting Company, Literary Road and West Third Street, and is installing equipment for the manufacture of pulverized coal for industrial and domestic uses, and the manufacture of burners for use with its fuel.

* * *

The Illinois Stoker Company, Alton, Ill., manufacturer of forced and natural draft chain grate stokers has been consolidated with the K-B Pulverizer Corporation, New York, manufacturer of the Pulverburner. The new company will make stokers and pulverized fuel equipment. The New York office is at 1948 Grand Central Terminal.

* * *

The Pollak Steel Company, Cincinnati, which is dismantling its local plant and disposing of equipment, has leased offices in the Temple Bar Building, Court and Main Streets, and will move its general offices there about December 15.

* * *

Four new sheet mills have been placed in operation at the Maryland plant of the Bethlehem Steel Company, at Sparrows Point, Baltimore. These new units add at least 35,000 tons to the company's annual capacity for producing black and galvanized sheets here.

* * *

The Central Iron Works, Chestnut Street, Rockford, Ill., has plans for the erection of a new addition to its plant, to be one story, 60 x 117 ft., reported to cost close to $30,000. Additional equipment will be installed.

* * *

The Penn Seaboard Steel Corporation, Franklin Bank Building, Philadelphia, Pa., is said to have plans for the rebuilding of the portion of its mill at New Castle, Del., recently destroyed by fire with loss reported in excess of $35,000, including equipment.

* * *

The Wesley Steel Treating Company, 651 South Pierce Street, Milwaukee, Wis., has plans for the construction of a new two-story plant, 25 x 75 ft., estimated to cost close to $40,000, with equipment.

* * *

The Guarantee Iron & Steel Company, 3847 West Lake Street, Chicago, Ill., has arranged for the purchase of adjoining property, 50 x 208 ft., for a stated consideration of $30,000, and plans the early erection of a new addition, reported to cost in excess of $45,000, with equipment.

* * *

The American Steel & Wire Company, Grove Street, Worcester, Mass., has completed details for an expansion and improvement program at its local mill, to consist of four one-story structures; the largest, 100 x 250 ft., will be equipped as a rod mill; another, 50 x 365 ft., will be used as a billet mill; a third structure, 90 x 390 ft., will be equipped for billet storage and kindred service; and the fourth, 50 x 100 ft., will be used as a power substation. Considerable additional machinery will be installed. The entire project is reported to cost more than $750,000. A. F. Backlin, company offices, Rockefeller Building, Cleveland, Ohio, is architect.

* * *

The Northern Pacific Railroad Company, Northern Pacific Building, St. Paul, Minn., is considering plans for the erection of a new plant at Laurel, Mont., for the manufacture of steel cars. The main unit will be equipped as an erecting shop; other one and two-story structures will be built. The entire project will cost close to $250,000, with machinery. O. M. Rognan is company architect.

* * *

The Southern Wheel Company, Commonwealth Building, Pittsburgh, Pa., manufacturers of steel car wheels, will soon break ground for a proposed new plant at the Toledo Terminal Railway and Airline Junction, Toledo, Ohio, consisting of a group of buildings to cost in excess of $800,000, with equipment. Contract for erection has been let to the A. Bentley & Sons Company, 201 Belmont Avenue, Toledo. Robert & Company, Bona Allen Building, Atlanta, Ga., are engineers.

* * *

The Birmingham Fabricating Company, 112-14 South Twenty-second Street, Birmingham, Ala., has work in progress on a new steel fabricating works on the Vandiver Road, near Thirty-sixth Street, Birmingham, consisting of two main buildings, 90 x 90 ft., and 80 x 100 ft., reported to cost close to $40,000. A list of equipment to be installed has been arranged L. H. White is president.

* * *

Officials of the Edgecombe Steel Company, Eleventh and Cambria Streets, Philadelphia, Pa., have taken out a New Jersey charter under the name of the Edgecombe Steel Corporation, capitalized at $250,000, to operate in the state. Property has been purchased on Frelinghuysen Avenue, Newark, N. J., 115 by 660 ft., as a site for a new factory branch and distributing works, with initial unit to be 100 x 300 ft., estimated to cost more than $50,000, with equipment. It is expected to begin work at an early date.

* * *

The Weirton Steel Company, Weirton, W. Va., has work in progress on a new one-story building to be equipped as a strip mill, reported to cost in excess of $350,000. It is purposed to have the structure ready for service early in the spring, and about the same time, it is planned to begin the construction of a new tube mill in connection with the general expansion and improvement program which has been under way for some time past. The entire project will represent an investment in excess of $5,000,000.

* * *

The Atlas Forging Company, 1501 South Fifty-fifth Court, Chicago, Ill., is said to have plans under way for the rebuilding of the portion of its mill recently destroyed by fire with loss reported in excess of $75,000, including equipment. The construction will cost close to a like sum.

To Expand Editorial Policy

BLAST FURNACE AND STEEL PLANT enters the New Year with reawakened enthusiasm. Always the magazine of personality—the one engineering magazine which has carried the message of technical development and progress direct to the men in the plants where steel is made, Blast Furnace and Steel Plant now fortifies itself by an expansion of editorial policy.

Rather than assume that a single editorial head possesses the variety of detail knowledge and the contacts involved in steel production technique, several men, each an authority in his field, will co-operate to secure and assemble into most interesting editorial form all outstanding features which are the natural outgrowth of the basic industry.

An Editorial Board has been created consisting of D. L. Mathias, formerly metallurgical engineer, Mackintosh-Hemphill Company, Pittsburgh; Fred Crolius, formerly superintendent of steam power engineering, Homestead Works, Carnegie Steel Company; Charles Longenecker, formerly assistant superintendent, open hearth department, Cambria Steel Company, Johnstown, and Don Watkins, formerly superintendent of blooming mills, South Side Plant, Jones & Laughlin Steel Corporation. These men will devote their energies to bring interesting and novel features about steel plant operation to our readers.

Editorial Board of The Blast Furnace and Steel Plant
(Top) D. L. Mathias, (Left) Fred Crolius, (Right) Charles Longenecker, (Bottom) Don Watkins.

Another function of this board will be that of personal contact with the readers of The Blast Furnace and Steel Plant. During the course of the year, the members will visit practically every steel plant in the United States and personally discuss steel mill problems with the operating officials of the plants.

They will also be glad to secure information on production problems and steel mill practice at any time for their readers and assist them in solving their minor difficulties.

If you have solved unusual steel mill problems and are proud of your accomplishments, write a story covering the subject and send it to the Editorial Board or if you do not care to write it yourself, advise the editor and he will arrange to have it written for you.

Weirton Assumes Commanding Position

Blowing in Their Second Large Blast Furnace Following Completion of Adequate River Transport Facilities, and Anticipates Further Important Rolling Mill Producing Capacity

By CLINTON H. HUNT*

IN a description of an important feature or element of a steel company's plant and producing equipment, a brief summary of the company's progress from its inception to its present day expanded proportions may serve to bring out more clearly the general aim or policy which has energized the organization.

The growth of Weirton has been rather extraordinary. Its policy has been persistent.

The Company Origin.

In May, 1905, there was chartered under the general laws of West Virginia, the Phillips Sheet & Tin Plate Company with the following officers: J. R. Phillips, president; W. H. Baldridge, vice president; E. H. Weir, secretary and general manager. It was capitalized at $150,000.

This organization immediately purchased the plant of the Jackson Sheet & Tin Plate Company, located at Clarksburg, W. Va.

This plant consisted of eight stands of rolls usually termed "mills," three of which were for rolling sheets and five for tin plate. The factory was in poor condition; the buildings were in need of repair and the machinery well worn.

Considerable difficulty was experienced by the organizers in putting the mill in condition to operate satisfactorily and turn out a product which would be acceptable to the users of tin plate and sheets. As a further obstacle for the new organization to overcome, President J. R. Phillips met his death within a month or two after the company was organized.

Present Officers.

Mr. E. T. Weir was elected president of the company; W. H. Baldridge remained as vice-president and D. M. Weir became treasurer.

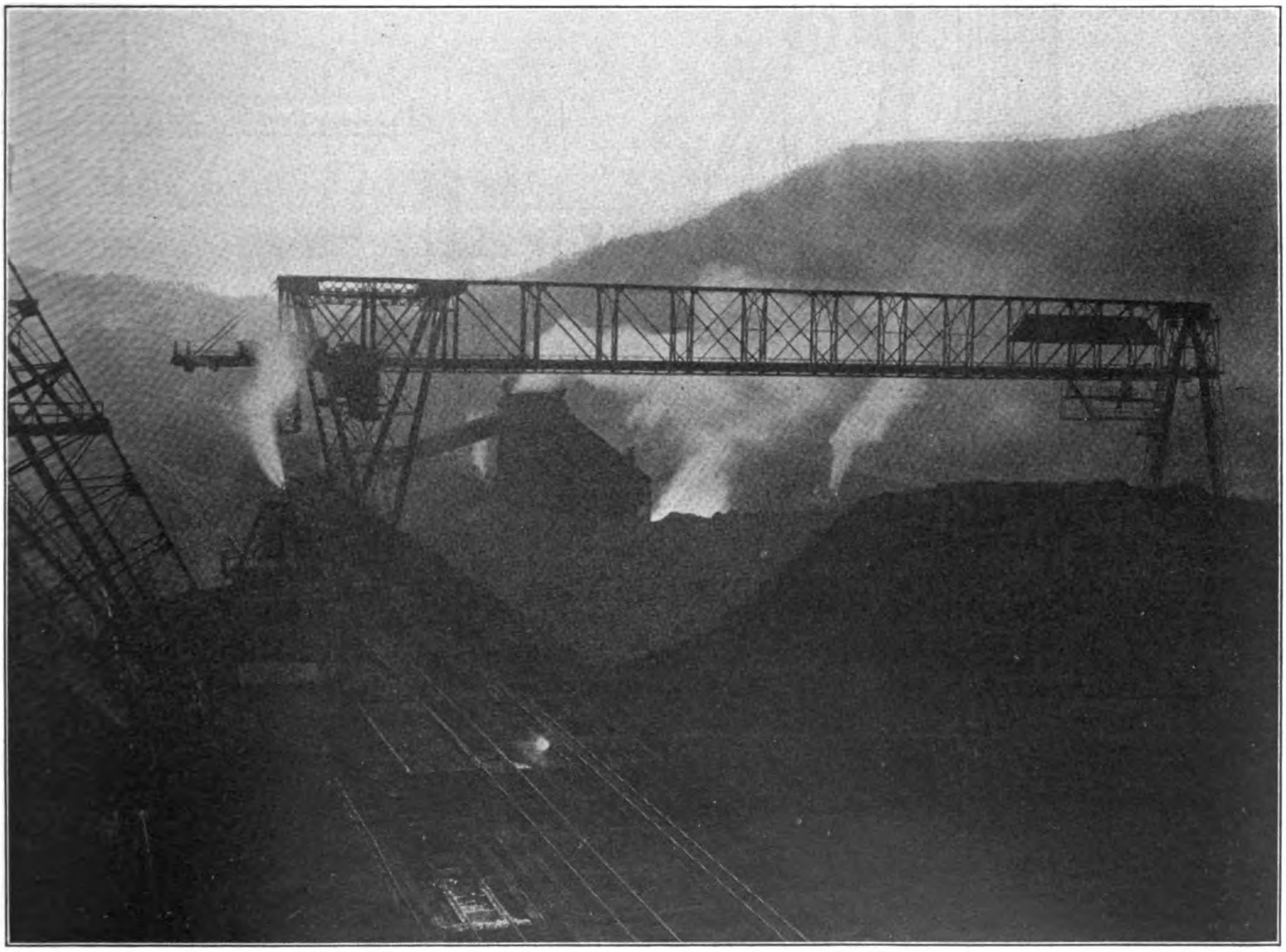

FIG. 1—The new ore bridge. This modern stock handling equipment has a maximum span of 281 ft. from leg to leg, with a cantilever extension. The bucket has a gross capacity of 10 tons.

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*Chief Engineer, Weirton Steel Company, Weirton, W. Va.

†Photography by Photo Products Company, Pittsburgh, Pa.

This organization was added to at various intervals up to the present, so that the principal officers of the present Weirton Steel Company, which was formerly the Phillips Sheet & Tin Plate, consist of E. T. Weir, president; D. M. Weir, W. H. Baldridge, J. C. Williams, H. D. Westfall, vice presidents; J. J. Watson, secretary; F. A. Hamlin, assistant secretary; R. J. Hanna, treasurer, and F. M. Hesse, assistant treasurer.

In 1908 an additional four mills were added, making the Clarksburg plant a 12 mill proposition. In 1909 the company was re-capitalized on a basis of $5,500,000 and purchased several hundred acres of ground at Crawford's Crossing, W. Va. At that time the property at Crawford's Crossing consisted of farm lands lying in the valley in which Holliday's Cove is now located.

New Mills Erected.

In 1909 a 10-mill tin plate plant was erected, a few houses were built for the benefit of those employees that might come from other points than the small towns surrounding this district, and a town by the name of Weirton was established.

In 1910 an additional 10 mills were added to the Weirton plant, making a total of 20 mills. In 1911 the company purchased and took over the plant and equipment of the Pope Tin Plate Company, located

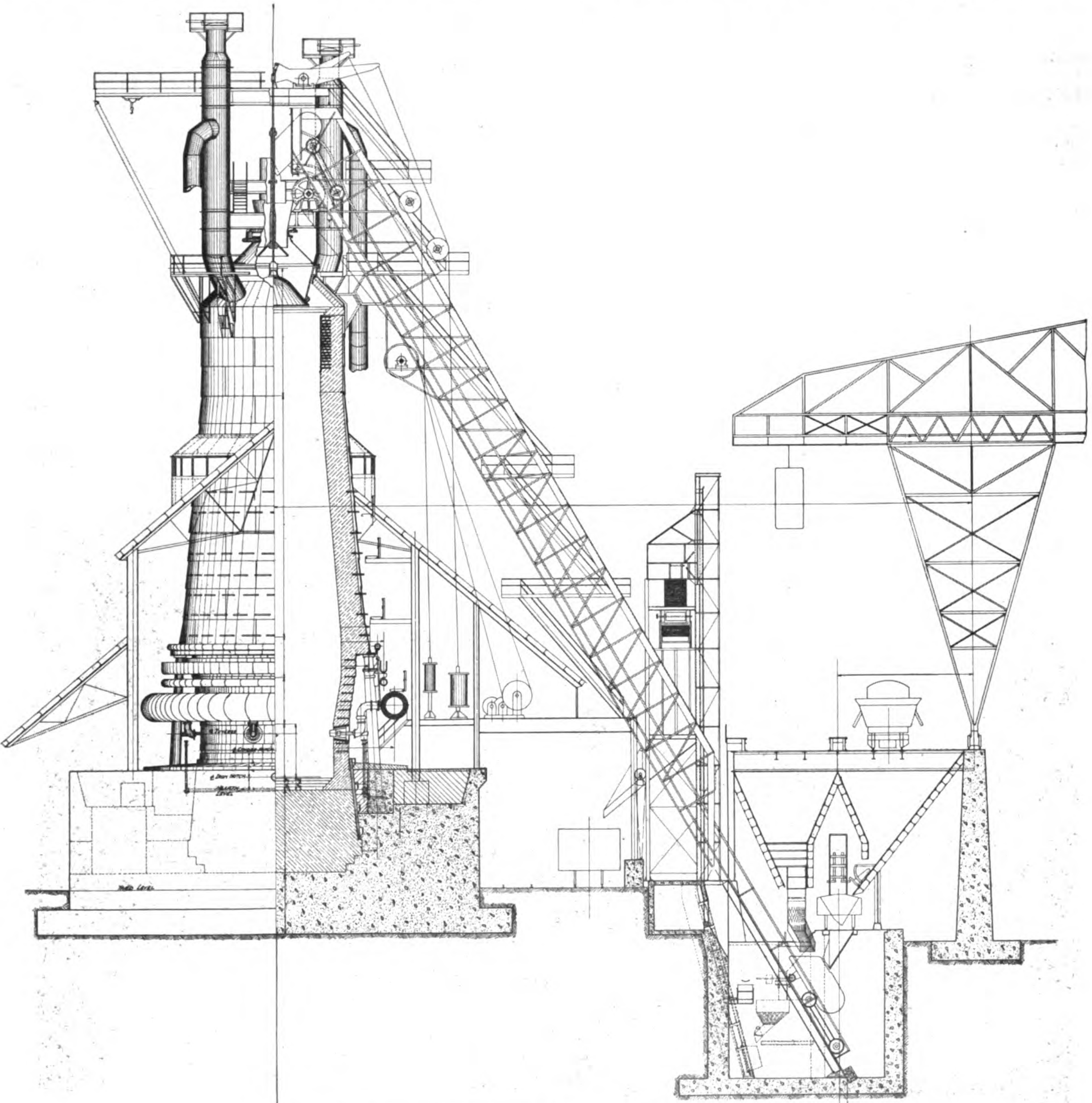
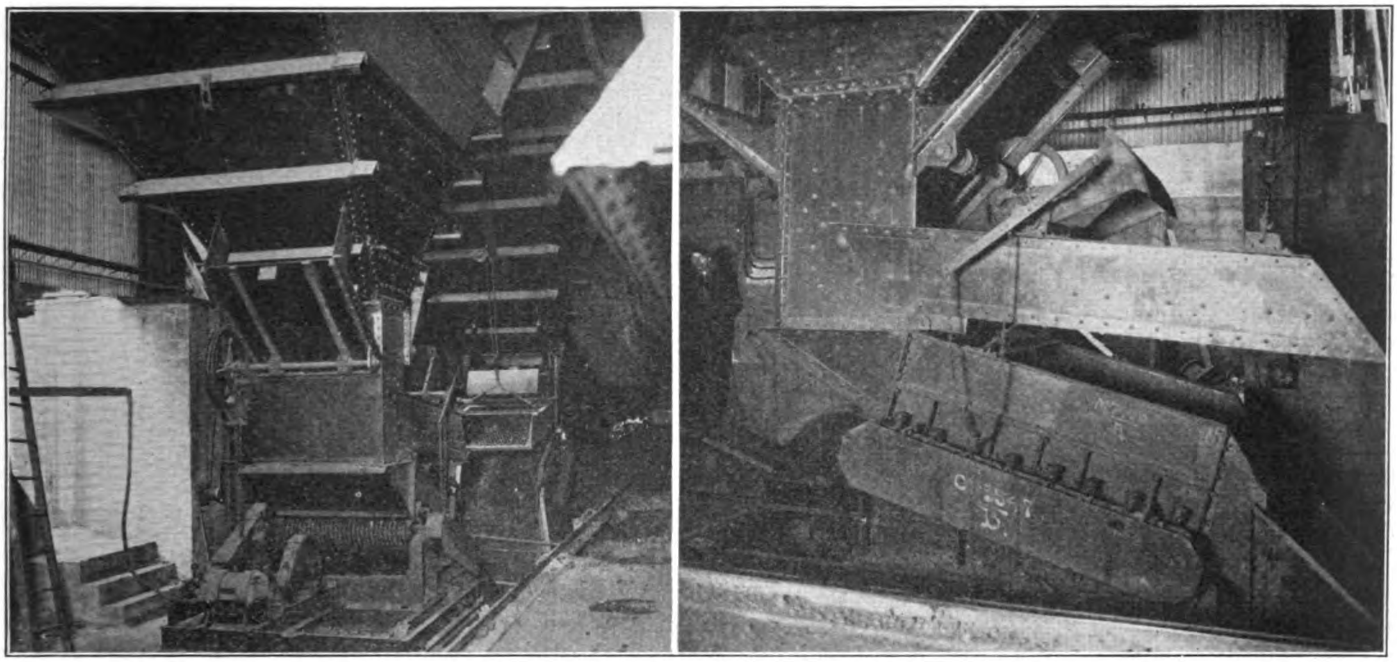


FIG. 2—A cross-section of the No. 2 Weirton blast furnace, showing in detail the relation of all important operating elements.



FIGS. 3 and 4—Close-up views of the Robins coke screening and conveying devices. By means of this equipment, an additional coke screening is performed, a better regulated furnace charge is obtained, and complete classification and recovery of the breeze results.

at Steubenville, Ohio, which consisted of a 12-mill tin plate plant.

In 1914 four additional mills were added to the Weirton factory and also another two mills added in 1915, bringing the total number of mills at Weirton up to 26. This gave the Phillips Sheet & Tin Plate Company 12 mills at Steubenville and 26 mills at Weirton, making a total of 50 mills which made the company the largest independent manufacturer of tin plate.

Another Acquisition.

In 1915 the firm took over the plant and equipment of the Weirton Steel Company, at Weirton, W. Va., which consisted of a cold rolled strip steel plant built in 1913 and then proceeded to increase the capacity of the former Weirton Steel Company so that it would be in position to not only produce a greater tonnage of cold rolled strip steel, but also to make its own raw material, consisting of hot rolled hoops and bands. This change was brought about by building two hot mills for the production of hoops and bands.

The name was changed on August 1, 1918, to that of the Weirton Steel Company. It was thought this change would cover the proposed products which the company expected to manufacture. The capitalization was raised to $30,000,000.

Sintering Plant Erected.

In 1919 a modern 600-ton blast furnace was completed and placed in operation. In 1920 there was completed and placed in operation an up-to-date steel plant consisting of seven 100-ton open-hearth furnaces, a 42-in. blooming mill and a 21-in and 18-inch continuous rolling mills. This blast furnace and steel works was also erected at Weirton on a part of the property originally purchased in 1909.

A sintering plant was placed in operation in 1923 to convert flue dust accumulated from the blast furnace into sinter so that it could be recharged into the furnace and the iron extracted.

Previous to this sintering plant starting operation the flue dust accumulated was shipped to the Youngstown district, converted into sinter and returned to Weirton or else the flue dust was stocked in the vicinity of Weirton awaiting the time when the Weirton Steel Company would build such a plant as they are now operating.

In July, 1923, the first coke was pushed from the new by-product coke plant, at the time of starting to operate this battery of ovens, consisting of 37, it was the only plant of its kind in the country, with the exception of five experimental ovens built some time ago in the Chicago district. This by-product coke plant is the most modern, efficient and complete unit in the

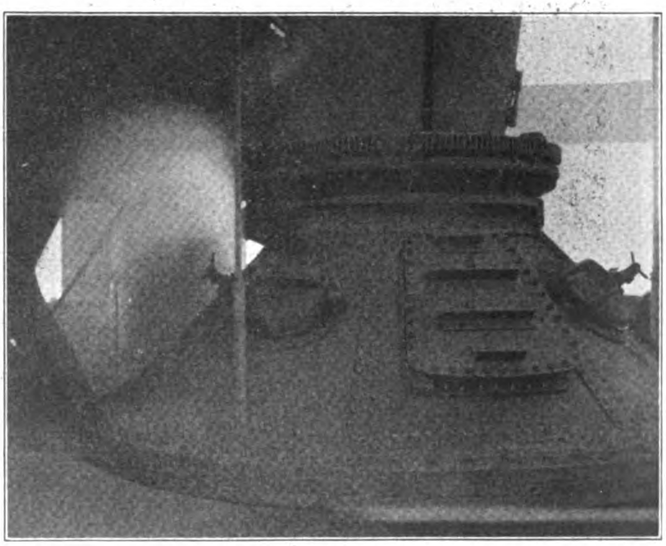


FIG. 5—A view seldom seen of the operating top of a blast furnace. Several important features are shown; the McKee revolving top, which in this case has been designed to repeat its discharge operation at shorter intervals; the McKee stock-line indicators, and the Freyn explosion doors.

United States and its operation is being watched closely by parties interested in the manufacture of by-product coke.

During the month of September, 1923, there was completed and placed in operation a new plant consisting of 12 mills for the purpose of manufacturing black and galvanized sheets and specialties.

This plant, like the by-product coke department, is considered by experts as being the most modern operation of its kind and there are a number of special features in connection with the construction of this mill which makes it quite different from any other.

$20,000,000 Payroll.

The construction program for 1926 and 1927 is by far the largest single schedule yet anticipated by the company. It will involve the expenditure of between $15,000,000 and $18,000,000, adding some 2500 to 3000 employees and bringing the Weirton Steel Company's annual payroll up to $18,000,000 or $20,000,000.

Description of New Blast Furnace.

The new blast furnace was blown in November 20, 1926. Exceptional time was made in in the construction of the new furnace, as the appropriation for this work was not granted until December 15, 1925, and the engineering department was not given authority to proceed with the new layout until January 1. This No. 2 blast furnace is located adjoining No. 1 furnace, with the usual ample area between that is required for the location of seven stoves.

The arrangement of hot blast and gas mains from the stoves is extremely flexible, it being possible by merely adjusting valves to use No. 4 stove with either No. 1 blast furnace or No. 2 blast furnace as the occasion may demand. Frontispage view gives a comprehensive idea of the furnace and stove arrangement. This view was taken from the immediate foreground of the new furnace and shows in an unfinished condition the elevator which gives immediate access to the top working level; also the single large concrete chimney.

The ore yard is 900 ft. long and has a storage capacity of 350,000 tons of ore. In addition it has a large capacity for the storage of limestone and coke, which naturally varies from time to time.

The car dumper has a normal capacity of 200 broad-gauge cars in 10 hours' time and weighs 400 tons. The ore bridge shown in Fig. 1 is 281-ft. span from leg to leg, with a cantilever over the bins of 58 ft. It is equipped with a bucket of 10 tons gross capacity. The bucket weighs 12 tons, while the bridge itself weighs 1,100 tons.

This view of the ore bridge was taken from the top of the new furnace and during a busy day's operations, as evidenced by the clouds of steam which slightly obscure the view. In the immediate foreground are shown the huge ore piles and the yard trackage with coke cars still loaded.

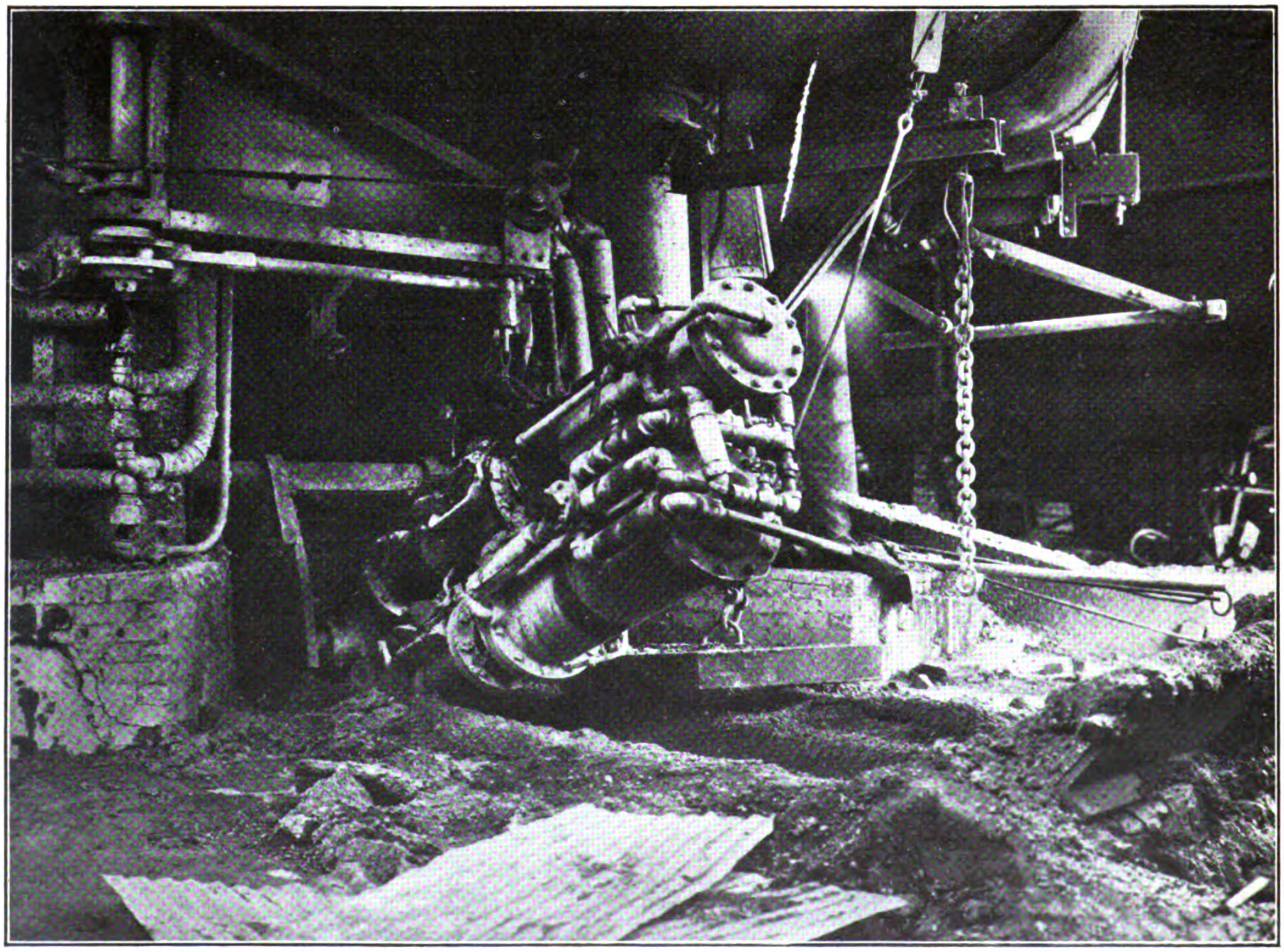


FIG. 6—No better view has been obtained of the double cylinder Brosius mud gun at work after the tapping of a furnace.

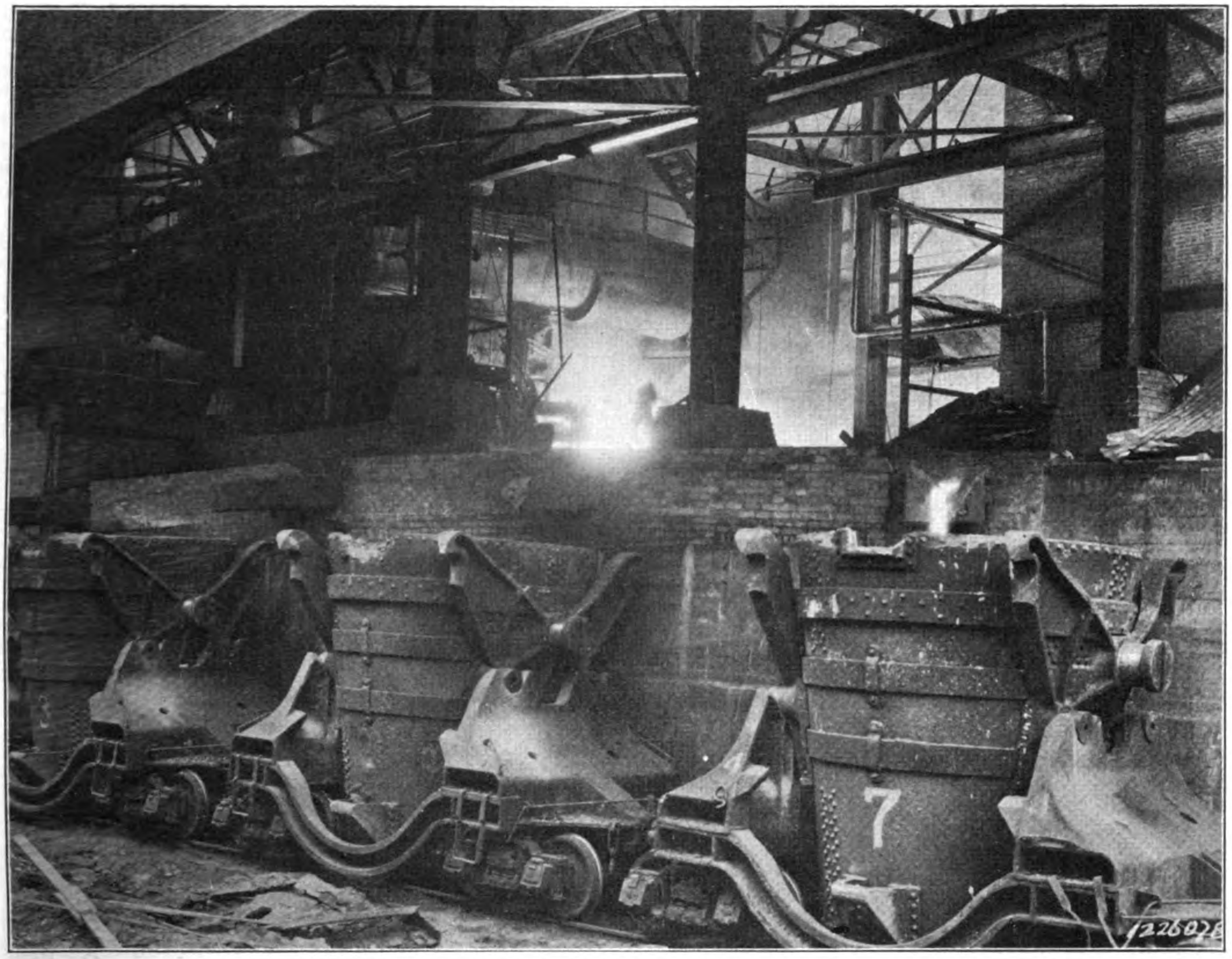


FIG. 7—In this picture, the glare of molten metal is emphasized by the figure of the operator working just to the right of the swinging mud gun. The flowing iron is entering the waiting ladle cars in the foreground.

Coke Screening.

This problem of coke screening has become a matter of great importance. The exacting demands upon the performance of the blast furnace in recent years has led to the development by the Robins Conveying Belt Company of a special design "Cataract" Grizzly for the particular purpose of screening the coke just before it is dicharged to the furnace skips.

This final screening completes the classification of the coke charge which starts at the coke plant, where the coke then drops from the screens to cars, causing breakage; again the drawing of the coke from cars to furnace bins and from furnace bins to furnace skips, causing further breakage. This screening, just before the coke is loaded into the furnace skips, is almost imperative.

With the realization of the inadequacy of bar or perforated plate screens between the furnace bins and the skips came the successful adaptation of the Robins "Cataract" Grizzly to this problem.

Fig. 3 shows the twin grizzlies for feeding the two furnace skip buckets. Fig. 4 shows one of the grizzlies more in detail. Each grizzly is mounted on a traveling carriage so that it can be withdrawn for replacements or repairs, and the emergency chute with cascade screen bottom plate, shown directly above the grizzly, can be lowered into place until the grizzly is again ready for service.

A small skip hoist, which the Robins Conveying Belt Company furnished for hoisting the material passing through the grizzlies to the Robins Savage Screen, which rescreens before discharge into separate bin. This bin is located directly behind the car in the foreground.

Breeze from the rescreen can be burned under boilers or disposed of in some other way. Oversize can be sold as domestic fuel or used in the blast furnace by placing it in a bin over the charging larry.

The bin system consists of one double gate coke bin and 19 ore and stone bins, each of which has a capacity for 300 tons of ore. The ore bins are a suspended type, with an equalizing gate with operating mechanism mounted on the 15-ton scale car. The transfer car has a capacity of 60 tons of ore. The coke breeze screened from the furnace coke bin is hoisted above yard level by means of a skip hoist.

The furnace itself is filled by a double skip hoist, each tub of 165 cu. ft. capacity and electrically operated. The furnace bells are operated by air cylinders with air supplied from the coal blast line, and with compressed air for emergency operation.

The furnace is of 800 tons normal capacity, but is expected to reach much higher rating, as operation at the end of the first 30-day period has shown a daily tonnage above its normal capacity. The furnace is lined with an Olive Hill sized brick, furnished by the General Refractories Company. It has a 21 ft. 6 in. hearth diameter, 24-ft. bosh diameter, 17 ft. 0 in. stock line diameter, and is 92 ft. 0 in. high. The cross section of the furnace is shown in Fig. 2. As is customary in all modern blast furnaces, this furnace is equipped with the McKee revolving top, which is shown in Fig. 5, which is an unusually good close-up view of this most important operating fixture.

While it seems almost unnecessary to discuss the revolving top construction of a modern furnace, so accustomed are blast furnace men to accept this as a matter of common practice, it is a fact that no other single development in blast furnace equipment has been as great a factor in the control and operation of present day huge furnaces with their almost unbelievable tonnage records. Fig. 6 takes us to the tapping floor level of the furnace and shows, in position, the recently improved Brosius double cylinder mud gun. The picture was taken immediately after the tapping of the furnace, and just after the mud gun has finished its operation.

An unusual view of the tapping operation was obtained and is shown in Fig. 7, in which the glare of the molten metal is emphasized by the operator in the foreground and with the mud gun at his left ready to swing into place. The stream of hot metal can be seen flowing directly into the ladle cars in the foreground. It is worthy of note here that many of the pictures shown in this article were taken during construction and before the cleaning up of debris had been consummated.

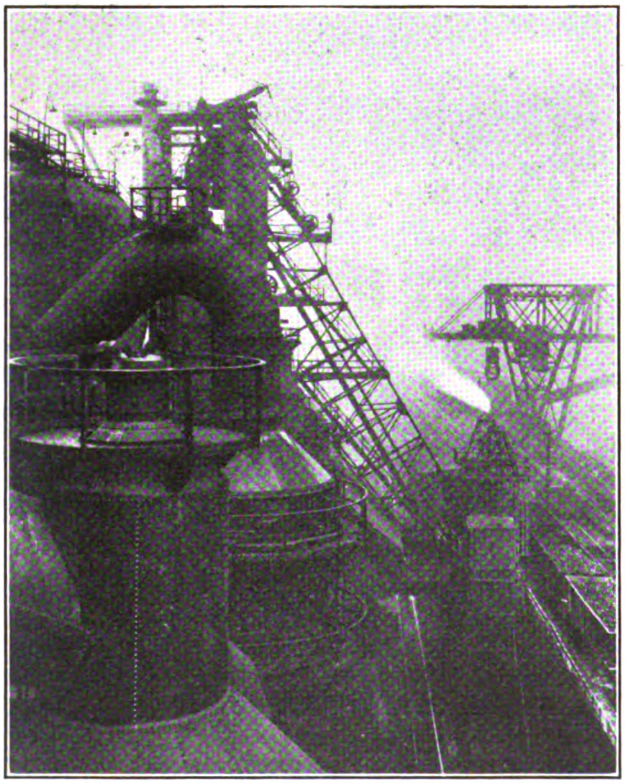


FIG. 8—Securing a good view of the tops of gas washers and valves is not an easy matter. This view, taken from the platform at the top of the new Weirton furnace, shows also the No. 1 furnace and one end of the ore-bridge, and skip hoist in the background.

The new stoves are of larger design than the original stoves and now complete an assembly of seven stove units for the two furnaces. These stoves are 100 ft. high, 25-ft. shell diameter with 4½-in. checker openings and constructed of 11½ in. by 6 in. by 2½ in. brick, with 91,400 sq. ft. of surface. All the brick used for lining the stoves was furnished by the General Refractories Company and manufactured at their Olive Hill, Ky., works. All stoves are equipped with Steinbart burners, automatically controlled by the Huessner system, and have Mathesius hot blast valves. The single concrete chimney shown in frontispage photograph is 8 ft. in diameter at the top and 225 ft. high, and was built by Heine Engineering Company.

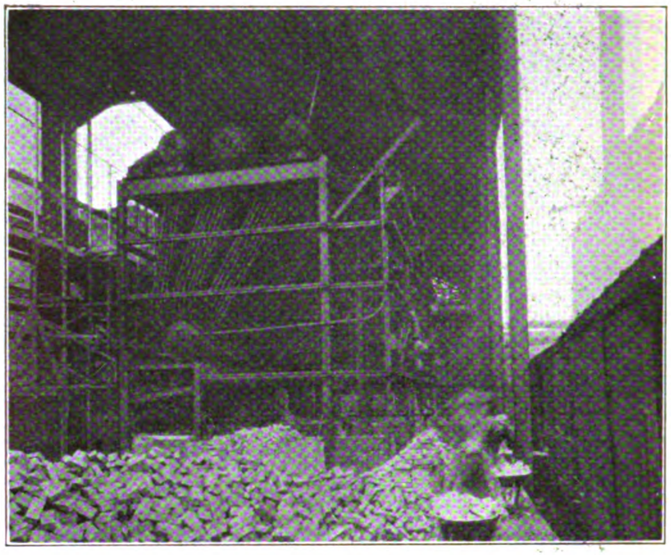


FIG. 9—This view of a modern boiler during construction gives some idea of its magnitude. In the foreground note the piles of Omega brick manufactured by the Crescent Brick Company and which were used to back up the boiler settings. Besides the boiler brick, all open hearth ladle brick used by the Weirton Steel Company are manufactured by the Crescent Brick Company.

The blast furnace dust travels from the furnace through the dust-catchers through a Kling goggle valve, to the whirler, Brassert washer, and dryer. Washed gas only is used in the stoves and unwashed gas in the boilers. Fig. 8 is an interesting view of the tops of this equipment, and shows in the background No. 1 furnace top, with its skip hoist, together with one end of the ore bridge.

Bell valves are also provided in the bottom of the dust-catcher and whirler to deliver the precipitated dust into cars, from where it is taken to the sintering plant. The sintering machine was designed by the American Ore Reclamation Company and is of the continuous type, 42 in. wide and 25 ft. 6 in. long. The capacity of the sintering machine approximates six to seven tons per hour.

Hot metal is tapped from the blast furnace into four 65-ton capacity Pollock ladles, which are lined with 9-in. fire brick. The cinder may be granulated in a pit at the furnace, or cast into cars for transfer to the cinder dump.

The bins with air-operated gates, the stove linings, the gas cleaning system, explosion valves, the chimney valves, the Mathesius valves, were designed by the Freyn Engineering Company.

The New Boilers and Power House.

The eight Heine boilers have 8,963 sq. ft. of heating surface each; they are built for 225 lbs. working pressure and are equipped with Foster Superheaters to deliver 125 per cent superheat. Fig. 9 shows the end boiler during progress of bricking in.

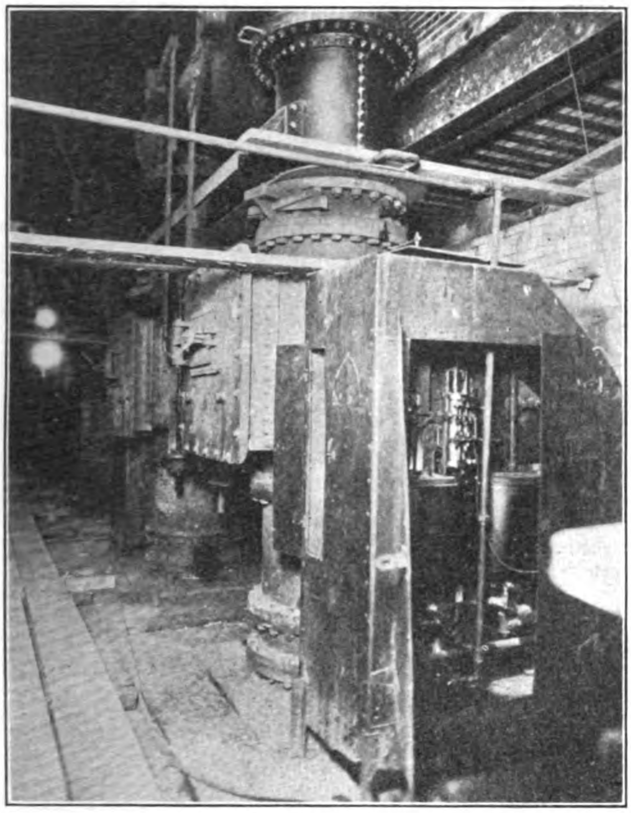


FIG. 10—Careful and efficient boiler operation demands close regulation. This figure, taken during construction work, shows each boiler controlled by Hagan regulation. The enclosing doors are here left open to disclose the moving elements.

Boilers are blast furnace gas fired through Steinbart burners controlled by Hagan automatic combustion controls. Fig. 10 shows the firing end of the boilers with the combustion control in the foreground. Unusually large combustion chambers are a feature of the design here employed; since the blast furnace gas is fired from the normal rear and the combustion takes place under bridge walls, high efficiencies at high ratings are assured.

High ignition temperatures, which are so essential to uniform combustion where blast furnace gas is the fuel, are mantained by Detrick suspended arches. This construction of flame openings allows a natural expansion of the gaseous fuel into the large combustion chambers, and a constant high CO_2 probably approximating 25 per cent under normal working conditions.

One additional boiler has been equipped for burning coke breeze; Coxe traveling grate stoker with the usual hopper design and water cooled back wall being provided. This arrangement overcomes the necessity of any unique boiler furnace design, complicated with the two fuel problem; each furnace in this case being designed to meet the conditions imposed by its particular kind of fuel, and is best adapted to burn that fuel continuously at high or low ratings, efficiently.

Cleanliness of external heating surfaces is decidedly important, where unwashed blast furnace gas is being burned under boilers.

This has been taken care of by the installations of Vulcan soot-blowers. Fig. 11 shows a cross-section of the Heine boilers with the location of the blowing elements. Each boiler is equipped with a 2-in. system of nine rotary elements, each element terminating in a cast-steel Monel metal trimmed Vulcan valve operating head.

The steam pressure is controlled by a McDonough Control System. All steam lines are covered with Johns Manville asbestos pipe covering.

The installation of a single 70,000 cu. ft. capacity turbo-blower completes the blowing equipment. The new turbo-blower, located within the main power house and next to the original Mesta blowing engines, is shown in Fig. 12. This turbo-blower, built by the Ingersoll-Rand Company, has an allowable working pressure of 35 lbs., and weighs approximately 200,000 lbs. It operates over a range from 2,300 to 3,500 rpm.

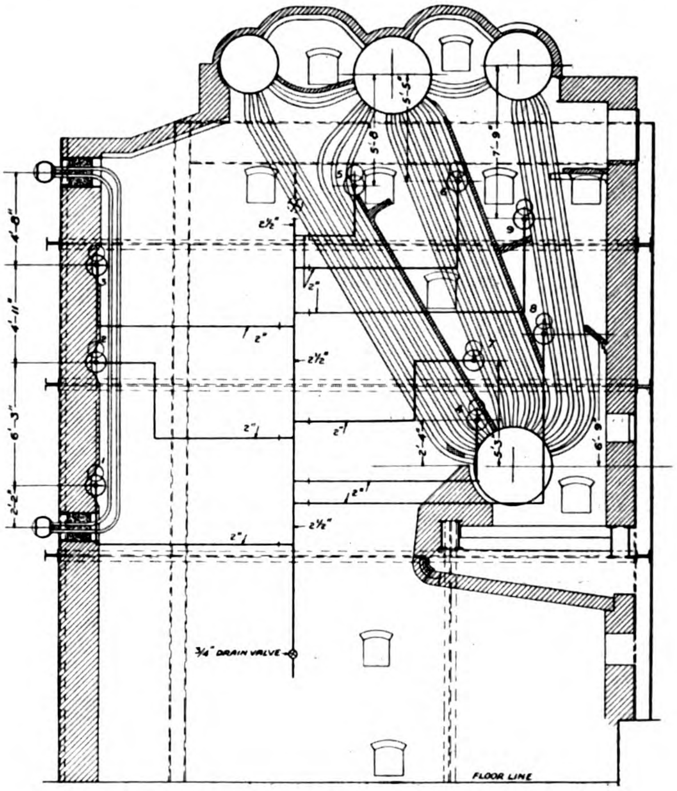


FIG. 11—The exact location of each soot-blower in a boiler setting is very important. This figure shows each element as it functions to keep a large blast furnace boiler cleaned of accumulated blast furnace dust. Note the spacious combustion chamber, and the bridge wall arrangement for rear end firing.

The revised pump house includes two new motor-driven pumps, each with 600-hp. G. E. motors. Immediately back of the first pump is located the turbine-driven pump. This arrangement of both motor-driven and turbine-driven pumps overcomes any possibility

General Data Summary

BLAST FURNACE

GENERAL DIMENSIONS:
Hearth—21 ft. 6 in. diameter
Bosh—24 ft. 0 in. diameter
Height—92 ft.
Cubical Contents—43,000 cu. ft.
12 columns, 12 tuyeres
Large Bell—13 ft. 0 in. diameter
Small Bell—5 ft. 6 in. diameter
Yard to center line iron notch—20 ft. 0 in.

NORMAL RATED CAPACITY:
800 tons per day

LINING:
General Refractories Co.—656,000 9-in. equivalent brick

REVOLVING DISTRIBUTOR:
Arthur G. McKee Company

PASSENGER ELEVATOR:
Otis Elevator Company

MUD GUN AND CINDER BOLTER:
E. E. Brosius Company

COOLING COPPER:
Falcon Bronze Company

INSTRUMENTS:
Bristol, Brown, Republic

BRASSERT WASHER:
15 ft. diameter by 64 ft. high

DRYER:
9 ft. 9 in. diameter by 17 1/3 ft. high
Dust Recovery Equipment

CAST HOUSE

DIMENSIONS:
Width of Furnace—62 ft. 0 in.
5-ton Traveling Crane over Cinder Pit
Crane Span—95 ft. 6 in.
Length—122 ft. 6 in.
Alliance Machine Company

CRANE:
4-ton Shaw Monorail Hoist
Manning Monorail—4-ton capacity

GAS CLEANING EQUIPMENT:
Dust Catcher—24 ft. diameter by 40 ft. high
Freyn Whirler—17 ft. diameter by 30 ft. high

HOT BLAST STOVES

GENERAL DIMENSIONS:
4 Stoves—25 ft. 0 in. diameter by 100 ft. 0 in. high
Checker Openings—4½ in. sq.
Checker Brick—11½ in. by 6 in. by 2½ in.
Total Heating Surface—Each, 91,401 sq. ft.
Two-pass, side combustion

LINING:
General Refractories Company—Each stove 52 by 900—9-in. equivalent brick

INSULATION:
Johns-Manville

FITTINGS:
Mathesius Hot Blast Valves
Freyn Chimney Valves
Steinbart Gas Burners
American H. E. Controls
Buffalo Forge Co. Fan—18,000 cu. ft. capacity

HOT METAL AND SLAG HANDLING EQUIPMENT

HOT METAL LADLES:
Pollack—Four 65-ton

CINDER CARS:
Pollack—Four 315-cu. ft. capacity

STOCKING AND CHARGING EQUIPMENT

ORE BRIDGE:
Heyl & Patterson—10-ton capacity bucket
Span—281 ft. 6 in.
Length Over-all—339 ft. 0 in.
Runway—900 ft.
Capacity—600 tons per hour

CAR DUMPER:
Alliance Machine Co.—Traveling type
Capacity—Twenty 100-ton cars per hour

ORE YARD:
Stocked with ...... tons ore

COKE BREEZE EQUIPMENT:
Robins Conveying Belt Company

SCALE CAR:
Atlas Car & Manufacturing Company—400 cu. ft., double compartment

General Data Summary

STOCK BINS:

19 Ore and Stone Bins
Capacity—Each, 275 tons ore
Volume Capacity—Each, 5,060 cu. ft.
One Central Coke Bin—220 tons
Volume Capacity—16,800 cu. ft.

HOIST ENGINE:

Lidgerwood Company—Single 72-in. dia. drum, 200-hp. motor
Skip Car Speed—300 ft. per minute
Skip Car Capacity—165 cu. ft.
Skip Car Travel—230 ft. (abs)

BELL OPERATING RIGS:

Air Cylinders, Stock Line Recorders, McKee Automatic Tester

BOILER HOUSE

BOILERS:

Eight . . .-hp. Heine Boiler Company
Steam Press—225 lb.
Steam Superheat—125 deg.
Eight boilers arranged for blast furnace gas
One boiler arranged for coke breeze and coal

SUPERHEATERS:

Foster; Power Specialty Company

FEED WATER REGULATORS:

Copes; Northern Equipment Company

SOOT BLOWERS:

Vulcan Soot Blower Company

COMBUSTION CONTROL:

Hagan Corporation

GAS BURNERS:

American Heat Economy Company
One Coxe Chain Grate—237 sq. ft. grate surface

STEAM FLOW METERS:

Bailey Meter Company

BOILER ARCHES:

M. H. Detrick Company

PIPE COVERING:

Johns-Manville

CHIMNEYS:

Rust Engineering Company
One 12 ft. by 225 ft.
One 15 ft. by 225 ft.

POWER HOUSE EQUIPMENT

TURBO-BLOWER:

One—Ingersoll-Rand
Maximum Capacity—70,000 cu. ft.
Maximum Pressure—35 lbs.
R.p.m.—

TURBO-GENERATOR:

One—General Electric Company
Capacity—7,500 hp.
R.p.m.—1,800
Voltage—6,600 volts

SYNCHRONOUS ROTARY CONVERTERS:

Two—Westinghouse Electric & Mfg. Company
Capacity—500 kw.

FEED WATER HEATER AND PURIFICATION PLANT:

Dravo-Doyle Company

BOILER FEED PUMPS:

Worthington Pump & Machinery Company

MAIN SWITCHBOARDS AND EQUIPMENT:

General Electric Company

PUMP MOTORS:

General Electric Company

AIR COMPRESSORS:

Worthington Pump & Machinery Company

PIPE COVERING:

Johns-Manville

STEAM TRAPS:

Crane Company

WATER SUPPLY

MOTORS:

General Electric Company

SWITCHBOARD:

General Electric Company

TURBINE GOVERNORS:

Fisher Governor Company

PUMP TURBINES:

Moore Steam Turbine Company

of lack of water, due to temporary interferences with electrical current supply.

The continuous Cochrane hot process water softening plant is the largest ever built and has a capacity of 160,000 gallons per hour.

Raw water is taken from a 30-in. main from the river pumphouse to the softening plant, where it is treated and heated before being pumped to the boilers. Exhaust steam from the air-rejectors, auxiliary pumps, etc., furnishes this steam requirement.

Boiler Feeders.

A glance through the pump room, adjoining the power house, gives evidence of the pride which the operating personnel takes in their equipment. The unit shown in the foreground consists of a 300-hp. Moore turbine-Worthington pump unit. There are three of these, designed to operate at 250 lbs. pressure and to deliver continuously 1,200 gallons of feed water each per minute.

A glance at the walls in the furnace blower's office shows the large and varied assembly of pyrometers, pressure recorders and continuous graphs, without which no operator could be expected to maintain accurate control of a modern furnace. Above each will be noticed its separate light, so that the furnace man in passing has merely to glance at any designed chart to draw for himself an immediate conclusion covering the operating conditions at that moment, or for the previous operating period. This is a typical Bristol assembly.

Loading and Unloading Docks.

Naturally, one of the most important pieces of equipment in the entire system of blast furnace and coke oven operation is the mechanical unloading docks or piers. The huge tonnages involved in the daily operation of modern furnaces require that manual labor be reduced to an absolute minimum.

This has been antcipiated at Weirton by the erection of a new river transport system. November 4 saw the opening of the largest coal docks between Pittsburgh and the Mississippi. Fig. 13 in panorama.

Continuous and Uniform Coke Supply.

This company's experience with the by-product coke as delivered from the original 37 Becker type ovens led naturally to an extension of the same type ovens as a source of coke supply for the new furnace.

Incidentally, these 37 were the first large battery of Becker type ovens installed in a steel plant. In the successful operation of a large furnace, the coke problem is a very serious consideration. Naturally an operator desires the maximum production from the blast furnace, from as large a percentage as possible of company ores and fuels.

In the case of Weirton, this is important, since the large company-owned acreage from which coal

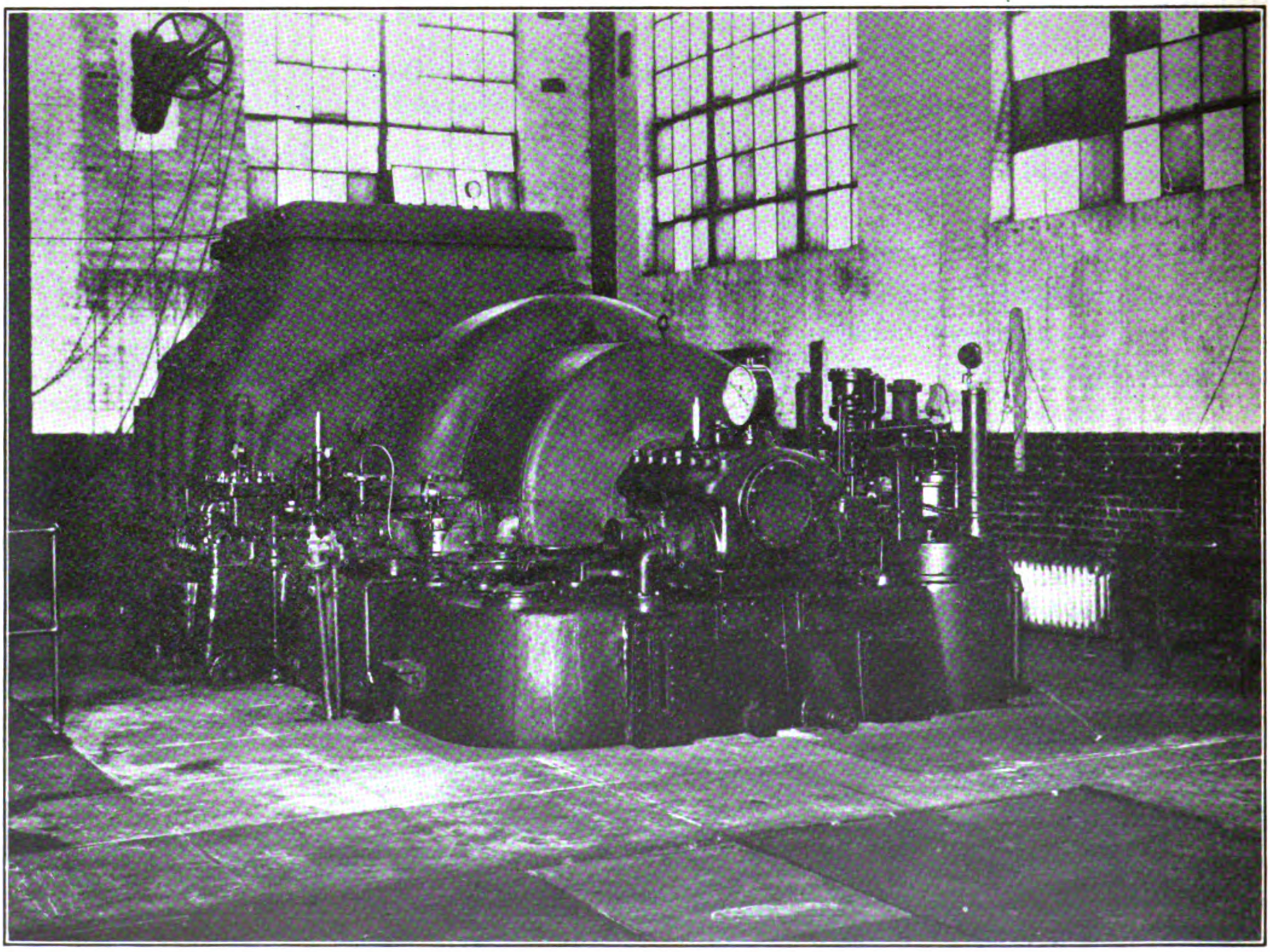


FIG. 12—Located at the end of the power house, parallel with the Mesta blowing engines, is the new Ingersoll-Rand turbo-blower. This unit is of 70,000 cu. ft. capacity.

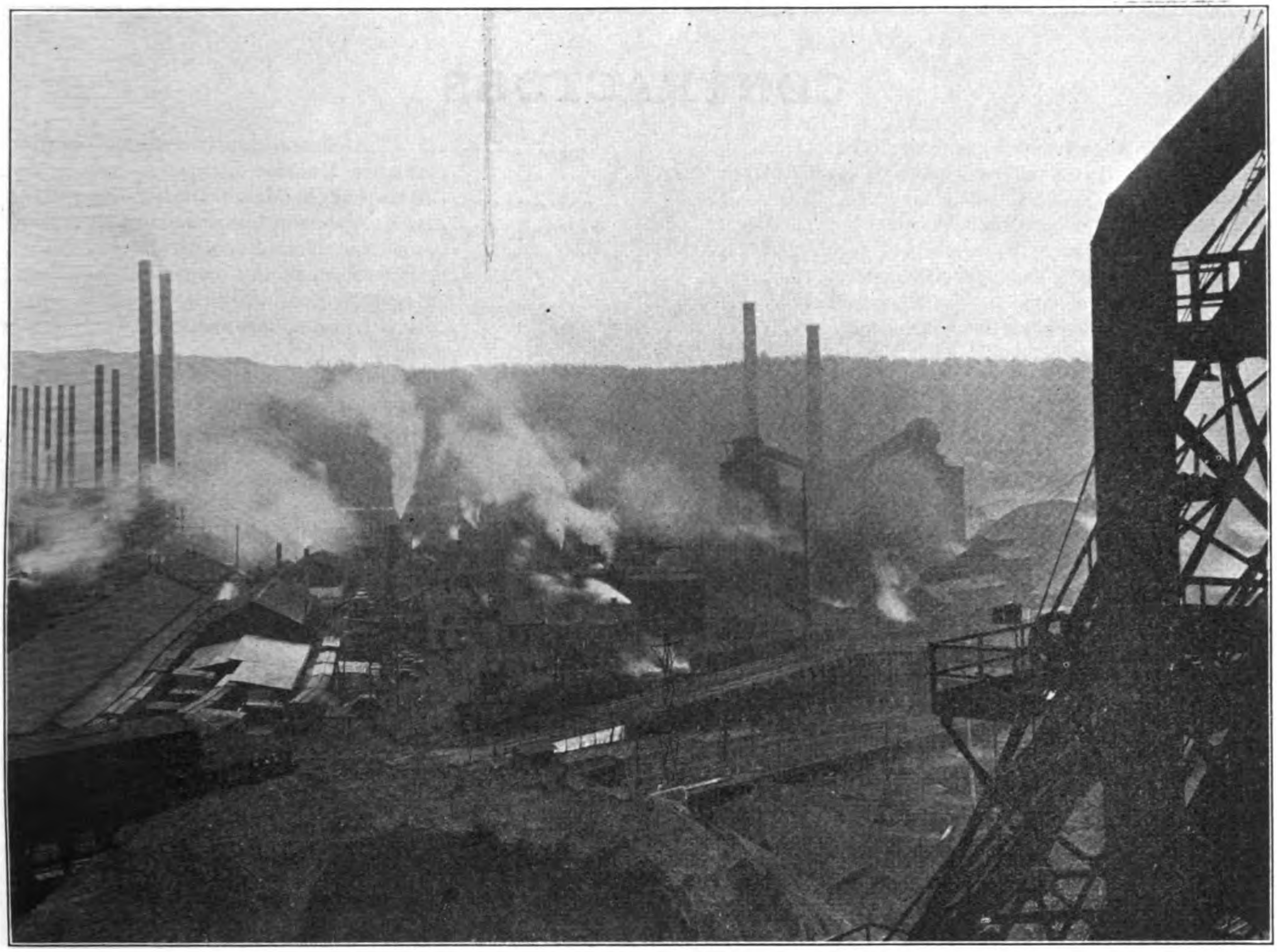


FIG. 13—The view from the top of the blast furnace is well worth reproducing. It gives an idea of a great steel plant in active operation. In the distance may be seen the coke plant, with the new 49 Becker type coke ovens, and on the left, the tin mills.

supplies are drawn to meet increasing requirements is located adjacent to the Monongahela river, in the Connellsville field. This coal is high volatile, and the necessities of the situation demand a mixture of as little low volatile coal as possible.

It has been found practical in the Becker type ovens to produce the quantity of coke required for steel making out of 100 per cent high volatile coal. Operation has demonstrated that using 100 per cent high volatile coal, coke of the proper characteristics can be depended upon.

A Glance Through the Open Hearth.

Fig. 13, taken from the top of the stoves of the new furnace, gives a comprehensive idea of proximity of the furnaces, coke oven plant, and on the left, the tin mill department.

Iron from the blast furnace and coke oven gas from the by-products ovens find their way to the open hearth plant, although most of the surplus coke oven gas is used at the finishing mills in heating and annealing furnaces.

While this is primarily a description of the new blast furnace and power house, reference may properly be made to the department which is the largest consumer of iron and by-product gas. There are ten open hearth furnaces—seven 100-ton furnaces and three 250-ton furnaces—housed in a building 190 ft. wide by 637 ft. long, with a height of 67 ft. The total width of the building is divided into three main bays. These furnaces are equipped with 31 Morgan gas producers.

The partition on the pouring side of the furnace is 60 ft. wide, the charging bay shown in the figure 85 ft. wide, with an additional 45-ft. "lean-to," which is a continuation of the charging floor.

In harmony with all producing departments at Weirton, the open hearth department works at high pressure, if the term may be applied to open hearth practice. All furnaces uniformly produce tonnage in excess of their rated capacities. To meet this condition, the furnaces are of very heavy construction throughout.

The furnace bottom is built up of a ⅞-in. steel plate bed, resting on a grillage of 30 I-beams supported on twelve 30-in. 190-lb. I-beams placed longitudinally, and resting on two massive concrete piers supporting the furnace.

The gas and air regenerators are built separate, 31 ft. 3 in. long inside, 2 ft. 7½ in. high from the bottom of the flues to the underside of the arch, and are respectively 9 ft. 6 in. wide inside.

The general work in the chambers is of standard type, made of 10½ in. by 4½ in. by 4½ in. first quality fire brick.

CONTRACTORS

Brickwork for blast furnace gas fired boilers	A. E. Anderson Construction Corporation
One 4-motor bucket handling I-beam monorail trolley	Alliance Machine Company
One scale car	Atlas Car & Manufacturing Company
Brickwork for No. 2 blast furnace	A. E. Anderson Construction Corporation
Steinbart stove burners	American Heat Economy Bureau
Car dumper	Alliance Machine Company
Cinder notch stopper	Edgar E. Brosius
Cast house and slag pit 1½ cu. yd. buckets	Blaw-Knox Company
Clay gun	Edgar E. Brosius
Transfer car	Brown Hoisting Machinery Company
Draft fans for Steinbart burners, boilers	Buffalo Forge Company
Coke braize stoker for No. 9 boiler	Combustion Engineering Corporation
Flat boiler arches	M. H. Detrick Company
Two turbo-blower condensers	Elliott Company
Gas washer and stove lining	Freyn Engineering Company
Hot blast valves; Baer explosion valves; chimney valves	Freyn Engineering Company
Stock bin gates	Freyn Engineering Company
Power house service pump motor	General Electric Company
Monorail switch	Harnischfeger Sales Corporation
Turbo-blower	Ingersoll-Rand Company
Ore handling bridge	Heyl & Patterson, Inc.
Insulation of hot blast stoves, hot blast mains, bustle pipes and downcomers	Johns-Manville, Inc.
Spillage elevator	Link-Belt Company
Flat arch for No. 9 coke braize boiler	Liptak Fire Brick Arch Company

The total capacity of the open hearth averages approximately 1,000,000 tons.

Future Developments Contemplated.

Construction has also been started on a new hot and cold rolled strip steel plant, which will more than double the present capacity on these two articles. The cost of this unit alone will approximate $5,000,000 and should be completed within the next year.

The remainder of the program consists of the erection of a mill for the manufacture of pipe and also adding eight mills to the sheet department which will double the capacity of that unit.

The foregoing refers entirely to the organization and development of the present day Weirton Steel Company so far as their operations are concerned. It shows the original Phillips Sheet & Tin Plate Company depending on others for their small requirements

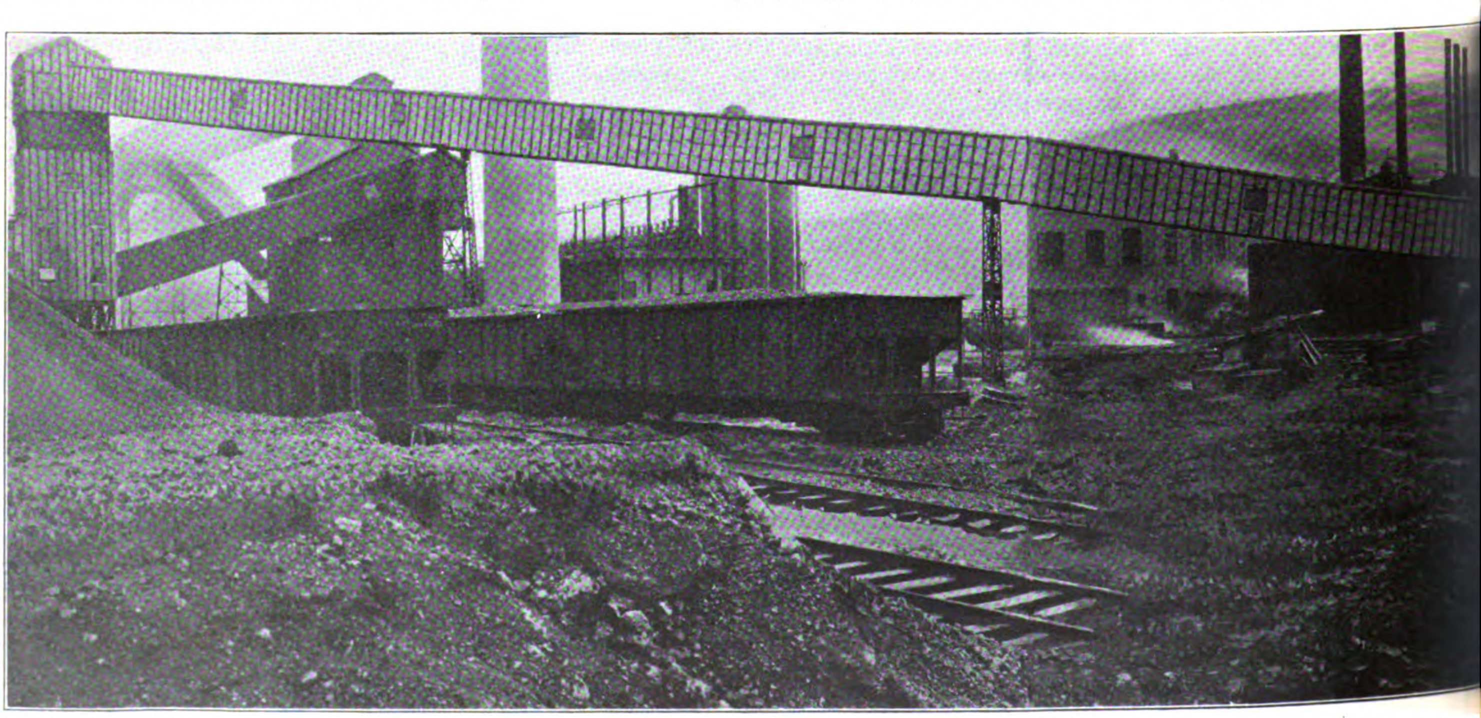


FIG. 14—So extensive is the new river-transport layout that a panorama is necessary to picture it.

CONTRACTORS

One automatic electric skip hoist	Ligerwood Manufacturing Company
Anemometer equipment for ore bridge	C. O. Burton
Kling goggle valves	Arthur G. McKee & Company
Revolving distributor	Arthur G. McKee & Company
Turbines	Moore Steam Turbine Corporation
Structural steel work, bins, skip and cast house	McClintic-Marshall Company
Water softening plant	Dravo-Doyle Company
One freight and passenger elevator	Otis Elevator Company
Lining for breeching	The Philip-Carey Company
Hot metal and cinder cars and ladles	William B. Pollock Company
Plate work	William B. Pollock Company
Transformer	Pittsburgh Transformer Company
Superheaters	Power Specialty Company
Coke screening and hoisting machinery	Robins Conveying Belt Company
Concrete chimneys	Rust Engineering Company
One 7500-kw. turbo-generator	Stephen A. Douglass Company
Draft fans for Steinbart burners—stoves	B. F. Sturtevant Company
19 sets of stock bin gates	Treadwell Engineering Company
Soot blowers	Vulcan Soot Cleaner Company
One gas compressor	Worthington Pump & Mchy. Corporation
Substation—MG set	Westinghouse Electric & Mfg. Company
500-kw.-MG set and switch equipment	Westinghouse Electric & Mfg. Company
Feed water pumps and service pumps	Worthington Pump & Mchy. Corporation
Electrical equipment for 10-ton unbalanced coke braize skip hoist	Westinghouse Electric & Mfg. Company

of raw materials to produce sheets and tin plate, and during the period of 21 years it demonstrates their efforts were principally in one direction—that is, to become self-supporting in every way so that with their present operations it gives them finishing mills which will take care of the production of the steel works.

At various times it was necessary to foresee the requirements of raw materials since the operations then in existence or those which were to come later, and as a result railroad equipment was purchased during the years 1917 and 1920 to protect the operations of the Weirton Steel Company in order that their plants might not shut down and employes be idle on account of the shortage of raw materials.

As a further protection on raw materials the Weirton Steel Company purchased iron ore property in the Lake Superior region, and several thousand acres of coal in Fayette and Washington counties, Pa., and

Coal received at the river front is transferred directly to the coke ovens shown at the extreme left.

also Brooke county, W. Va. These properties were purchased as a protection for the future operations of the various plants of the company and protects them on these two materials for probably the next 50 years.

The explanation shows to some extent the abnormal growth of the organization formed in 1905 and as a summary it shows the original Phillips Sheet & Tin Plate Company capitalized at $150,000 in May, 1905, operating in a very difficult manner an eight-mill plant at Clarksburg, W. Va., employing some 400 or 500 people and producing tin plate and sheets totaling approximately 25,000 to 28,000 tons per year. Whereas, over a period of 21 years, or up to the present time they have an investment of over $40,000,000, or almost 300 times the original capitalization, soon employing about 10,000 people, not including the iron ore mines and with an annual production of various commodities which will be approximately as follows:

Coke, 550,000 net tons.

Pig iron, 550,000 gross tons. Blast furnace sinter, 60,000 gross tons.

Steel ingots, 1,000,000 gross tons.

Sheet bars, slabs and billets, 850,000 gross tons.

Tin plate, 275,000 net tons.

Hot rolled strip steel, cold rolled strip steel, 575,000 tons.

Black and galvanized sheets, 70,000 net tons.
Sulphate of ammonia, 11,000 net tons.
Tar, 10,000,000 gallons.
Light oils, 2,750,000 gallons.

In conclusion it is interesting to note that the new Weirton blast furnace is almost within a stone's throw from where the first iron furnace west of the Allegheny Mountains was built more than a century and a quarter ago.

The furnace as it stands today is only an historical relic as it remains only partly intact. However, there is quite enough to gain a good idea of the nature of its structure, size and general proportions. The remaining portions would indicate that it had an inside diameter ranging possibly from 10 to 12 feet, while the outside diameter must have been close to 25 feet. The height is a matter of conjecture, as the upper portion has evidently fallen away or has been torn down. It would seem, however, that it might have been something over 20 feet high, perhaps higher.

The refractory was well cemented together and still remains intact. It is composed of high-grade sandstone and seems to have withstood the heat without much deterioration.

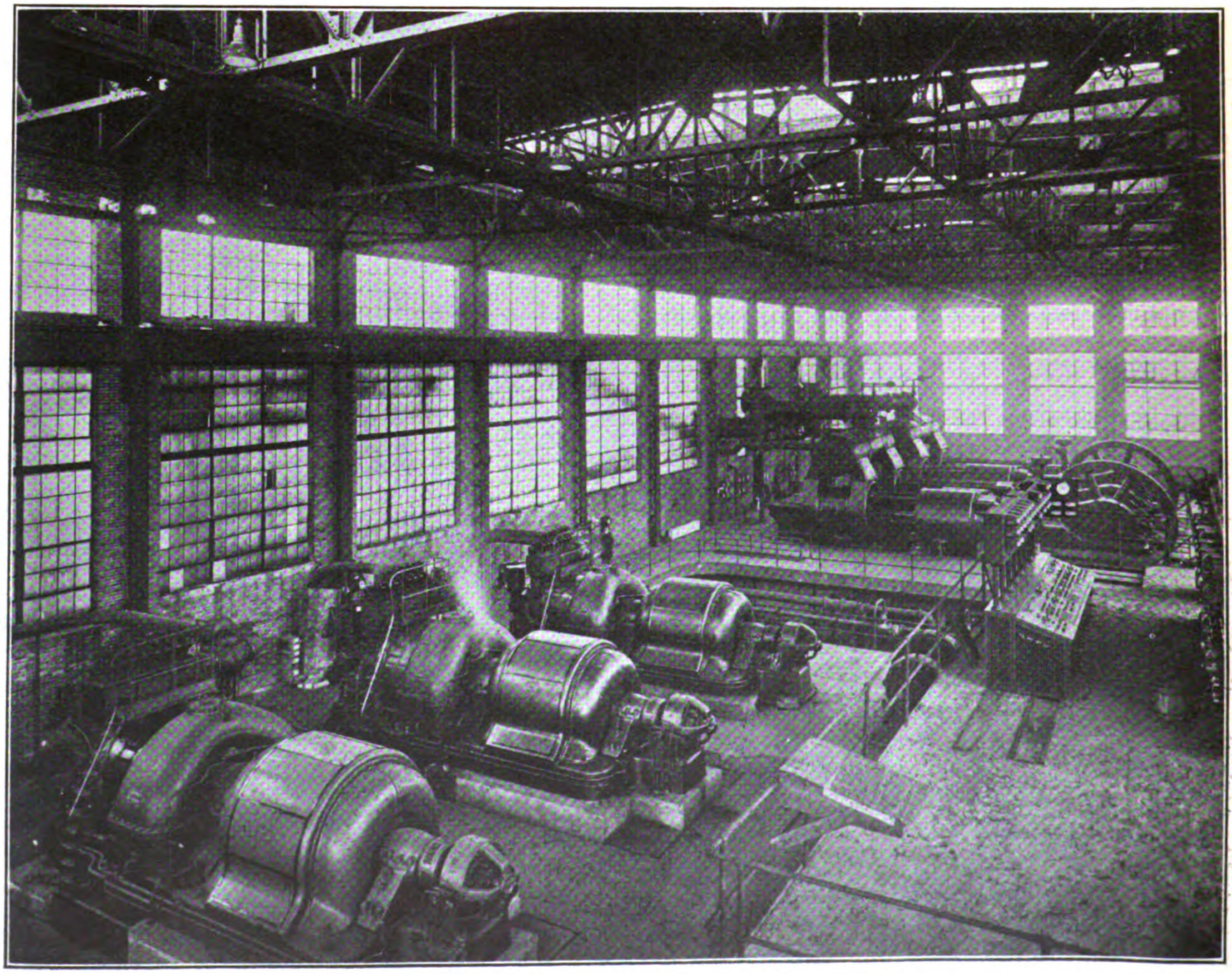


FIG. 15—An excellent view through the power house. In the left foreground are the turbo-generators. In the right background, the Mesta blowing engines, and behind these, the new turbo-blower, shown in Fig. 12.

The Blast Furnace and Steel Plant

Member of the Audit
Bureau of Circulations

PITTSBURGH, PA., JANUARY, 1927

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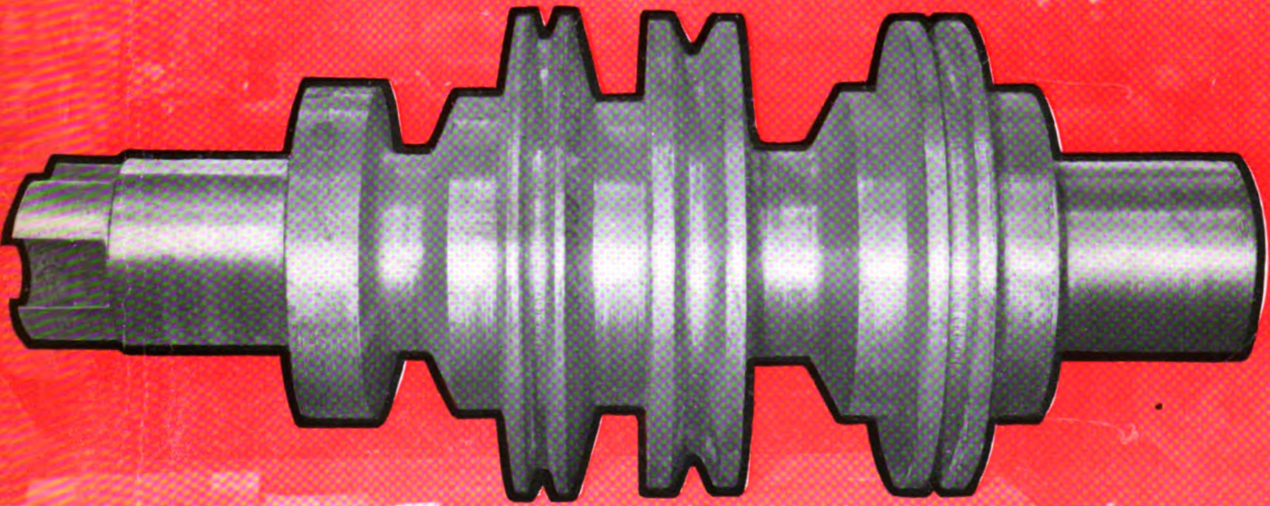

Cast Steel 36″ Mill Structural Roll
Largest diam. 51⅞″ x 78″ long. Body weight 32,880 lbs.

Wheeling Mold & Foundry Company
Wheeling, West Virginia